1947, No. 2 JUNE 30

COPEIA

Established in 1913

PUBLISHED BY
THE AMERICAN SOCIETY OF ICHTHYOLOGISTS
AND HERPETOLOGISTS

Copeia *1947, No. 2* *June 30*

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Published quarterly by the American Society of Ichthyologists and Herpetologists, at the Museum of Zoology, University of Michigan, Ann Arbor, Michigan, under the Act of August 24, 1912. Acceptance for mailing at special rate of postage provided for in Section 1103, Act of October 3, 1917, authorized February 11, 1924.

Breeding Behavior and Early Development of the Mudsucker, a Gobiid Fish of California [1]

By George F. Weisel, Jr.

ONE of the most remarkable fishes of the Californian fauna is the mudsucker or long-jawed goby, *Gillichthys mirabilis* Cooper. Rather large for a goby, it reaches a length of at least 8 inches. It is common in the bays and estuaries of southern California and northwestern Baja California. It has been reported from as far north as Puget Sound (Jordan and Starks, 1895: 839). Records from the Gulf of California, as that of Evermann and Jenkins (1891: 162) from Guaymas, were based on related species, *Gillichthys detrusus* Gilbert and Scofield and *G. seta* (Ginsburg).

The mudsucker is the chief bait fish of southern California. It is reported that many thousands per week are harvested and sold. Its popularity is attributable not only to its suitable size and extreme hardiness but also to its ability to survive for several days in fresh water. Consequently, it is widely used for fishing in lakes as well as in the bays and seas. Its inability to propagate in fresh water renders it a safe fish to use as bait.

Little has been published concerning the life history of *Gillichthys mirabilis,* and part of the little that has been written is of doubtful validity. Eigenmann (1892: 159, pl. 15, fig. 12) figured the young, which is remarkably unlike the adult, and stated that the species begins to spawn in the San Diego area about the end of March, at which time it ceases to feed and retires to crab holes. Actually it spawns as early as January and appears to move about at night during all seasons. Hubbs (1921: 1–3) described the young as a distinct genus and species, *Aprolepis barbarae,* but later (1926: 3) corrected the error. Barnhart's statement (1936: 82) that it is most abundant in sloughs, and hides in the holes of the mud banks is true, but his indication that it hibernates in winter is not confirmed. Young and Fox (1937: 1) found many males with motile sperm and females with enlarged ovaries in May and June. Observations by bait dealers and by me confirm this finding and show that a few females mature as late as July.

The breeding behavior of the mudsucker has not been described. Some bait dealers have attempted the artificial propagation of this fish but report lack of success. Though it has been exhibited for long periods in the public aquaria of the Scripps Institution of Oceanography and at Steinhart Aquarium in San Francisco, no one has seen it spawning. The spawning of a pair in a laboratory aquarium at Scripps Institution was therefore observed with much interest. This observation prompted the preparation of this paper.

Breeding Behavior

On January 1, 1946, several adults of *Gillichthys* were procured for experimental purposes from a bait dealer in San Diego. They were placed in 20-gallon stock tanks with a thin bottom layer of fine gravel. Nest building activities were first noticed in the middle of January. Closer observations revealed that a large goby had established territory in the most secluded

1 Contributions from the Scripps Institution of Oceanography, New Series No. 321. Acknowledgment is due to Dr. Carl L. Hubbs and his students for their aid in collecting material, and again to Dr. Hubbs for suggesting the problem and for his critical reading of the manuscript.

corner of a tank and was constructing a nest. He regularly drove his twelve tank companions away from this area by biting them on the head and along the sides. In a week's time the chased fish were content to take residence in the previously avoided parts of the tank where they were most subject to disturbance by passers-by.

In the construction of the redd, a square foot of crushed gravel about 1½ inches deep was cleared from the bottom of the aquarium. The task took a full two weeks of intermittent labor. Most of the gravel was moved by either a fanning motion of the tail or by a quick rolling of the body. Not infrequently the nest builder carried gravel in his mouth to the opposite end of the tank.

On several occasions a startling display of combat was exhibited. This took place whenever a large male ventured into the nesting territory of the established male. The first sign of approaching battle was the rigid expansion of dorsal and anal fins. In a few seconds the anal and pelvic fins were suffused with sooty-black. This color appeared later on the dorsals and then extended as a less intense darkening over the entire body. The defender was first to present the next and most frightening battle array. He opened his mouth to its fullest extent, which in *Gillichthys* presents a huge gape and spreads the maxillaries out at right angles to the body (Fig. 1). In this pose, the membrane between the maxillaries and dentaries stretches sail-like on either side of the mouth. The adversary followed example and the two squared off, pushing against each other jaw-to-jaw. This was repeated two to five times, and twice in six trials the guardian pushed the intruder back the full length of the tank, 2½ feet. The battles terminated when the intruder retired to the end of the aquarium farthest from the redd.

Incidentally, it may be mentioned that the rich vascularization of the jaw membranes (Fig. 1) leads one to suspect that they serve as an accessory respiratory apparatus. Such additional respiratory devices are not uncommon among the gobies. *Typhlogobius* has subepidermal blood vessels (Ritter, 1893: 90–93), *Periopthalmus* a modified caudal (Hickson, 1889: 30–31), and *Bathygobius* modified pectorals (Beebe, 1931: 63–65) for use in respiration. However, adult mudsuckers did not gape when kept in a sealed vessel of water until they nearly suffocated.

The breeding color is transitory and disappears as quickly as it appears. This rapid color change has been noticed in *Gobiosoma robustum* by Breder (1942: 62) and in *Bathygobius soporator* by Beebe (1931: 61–63). The courtship hues of *Gillichthys* are not confined to the males, nor is the jaw-spreading and pushing. Mature females were frequently seen to assume the black coloration and also to push off males and other females that happened to swim into their acquired area. Neither the pushing nor the color change occurred among the smaller gobies. Nor did it take place other than in the spawning season.

The sexual dimorphism in this species is slight. In the aquarium the mature sexes may be distinguished only by close inspection. The broad and swollen genital papilla of the female contrasts with the more pointed papilla of the male. The abdomen of the ripe female is fuller and has a yellowish tinge due to the underlying ova. Less obvious differences are the blunter

nose of the male and the slightly greater width of the maxillary tip. There are no patterns or general coloration which can be used for a definite separation of the sexes.

On February 5, I removed all fish with the exception of the nest guardian and what was obviously his chosen mate. She had often been seen by his side in the nest, whereas any other fish was immediately driven off. Remaining calmly in their secluded corner, the pair exhibited little activity. The female often clung with her pelvic fins to the side of the aquarium.

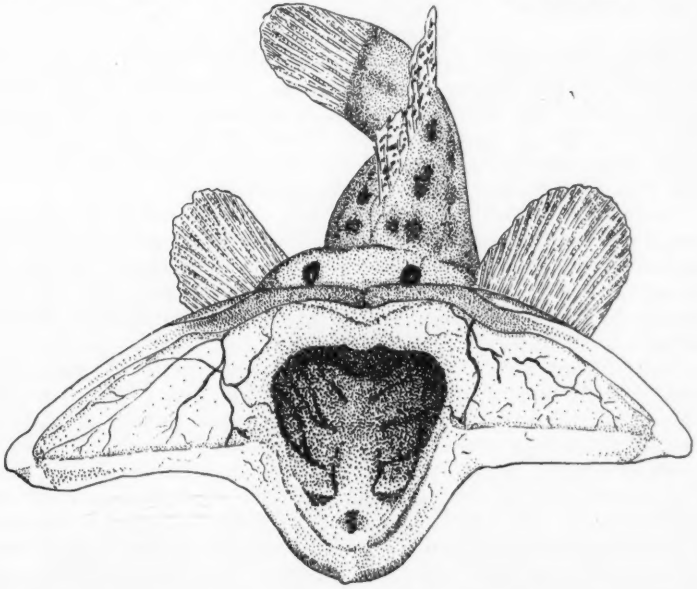

Fig. 1. Adult *Gillichthys mirabilis* in combat pose. Drawn from photograph by Paul Williams.

The pair spawned, unobserved, during the night of February 6–7. In the morning several masses of eggs adhered to the glass walls in the nesting corner. The male lay as close as possible to the eggs. When tickled with a rod, he refused to budge from his place of guard. No fanning of the eggs was noticed. The female was at the end of the tank away from the nest. When driven into the nest, she was ignored by the male.

The egg masses adhered loosely to the glass. They were placed as far up as 6 inches from the bottom of the tank, which would indicate that the female must have pressed herself against the side in a vertical position during the extrusion of her eggs. Most of the eggs were in two large clusters. There were six separate groups of from four to twenty eggs close to the two large masses. Very few eggs were on the floor of the redd. One of the larger aggregations of eggs was removed twice during the day and studied under a microscope.

The male remained alongside the eggs all day. The female exhibited only indifference. In contrast with the usual voracious habits of the species, neither of the pair ate for several days after the spawning. Nor had they shown interest in food for two days previous to the act.

The morning following these observations, we were disappointed to find that most of the eggs had been eaten. Only a couple dozen scattered eggs remained. These were carefully removed and placed in a glass container. They provided the material for the following descriptions of all egg stages, except the earliest.

Eggs and Embryos

The eggs are laid in large clusters which to the unaided eye resemble hundreds of minute yellow grapes on a stem. Their specific gravity is but slightly greater than that of sea water. It was estimated that 4,000 eggs were laid by the one spawning female. Nearly all of the eggs were fertile. A gravimetric count of eggs removed from three other mature female ranges from 4,000 to 9,000, varying with the size of the fish.

Under magnification, the few unfertilized eggs included in the spawned mass are spherical. The yolk mass nearly fills the egg (Fig. 4). Six of these eggs measured 1.03 to 1.18 mm. in their greatest diameter. At one pole of the egg is an interwoven group of adhesive threads. Directly after fertilization the vitelline membrane expands and the egg assumes its typical elliptical shape.

The fertilized egg is shaped like an Indian club. Its round yellow yolk mass is usually situated toward the large end of the club. There is a wide hyaline perivitelline space. The opaque yolk, which occupies only about one-third of the area within the vitelline membrane, has many oil globules. Numerous adhesive threads are bunched at the narrow pole of the long axis. These threads entwine about a central stalk from which the eggs dangle in clusters (Fig. 5). The major axis of the fertilized egg is 2.77 to 3.37 mm. and the minor axis 1.06 to 1.13 mm. The yolk diameter varies from .75 to .87 mm.

On the first day after fertilization a rounded blastoderm fits like a cap over the yolk (Fig. 6). The blastoderm is directed toward the attached pole in 95 of 100 examples studied. The remainder have the cap toward the unattached end. Twenty-four hours later the blastoderm has grown around the egg and there is a well developed primitive streak with an anterior swelling, the anlage of the embryonic head (Fig. 7). Many fine, relatively short gelatinous threads cover the surface of the membrane at this stage and those that follow. These threads do not entwine and adhere to one-another as do those at the attached end. They were not noticed previous to this time, and a re-examination of some preserved earlier stages did not reveal them. Literature and illustrations of American gobies which were reviewed gave no intimation that threads other than at the pole of attachment were present on the eggs of related species.

By the third day of development the embryo has definite outlines. The eye is forming and the embryo is much less opaque than the yolk. On the fourth day there are ten to fifteen somites (Fig. 8). As differentiation continues, the yolk becomes smaller and the number of oil globules is reduced. The embryo becomes progressively more transparent but the yolk remains

opaque. Most of the embryos are so situated that the head is directed toward the pole opposite from the attached end. This polarity was noticed in *Bathygobius soporator* by Breder (1943: 6) and an opposite polarity in *Gobiosoma bosc* by Hildebrand and Cable. Measurements of the egg's longest axis taken twice daily showed no elongation takes place after the initial lengthening that follows fertilization. The major axis remains approximately 3.23 mm.

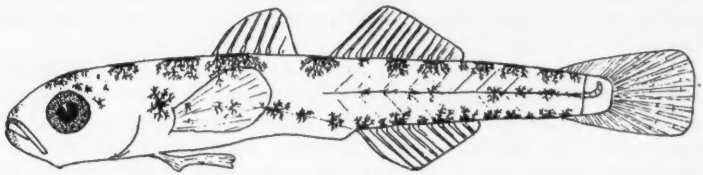

Fig. 2. Postlarva 11.5 mm. in total length.

Movement of the embryo is evident on the fifth day. Most of the features of the six-day embryo (Fig. 9) are now evident. The fin folds contrast with the rest of the embryo by reason of their greater transparency. The posterior gut, the auditory vesicles, and the vertebrae are differentiating. By the sixth day the embryo nearly fills the space within the membrane. The embryonic fish are now 2.54 to 2.65 mm. long. The shape of the vitelline membrane has not changed since the first day. It is apparent that it anticipates the shape of the embryo in its later stages.

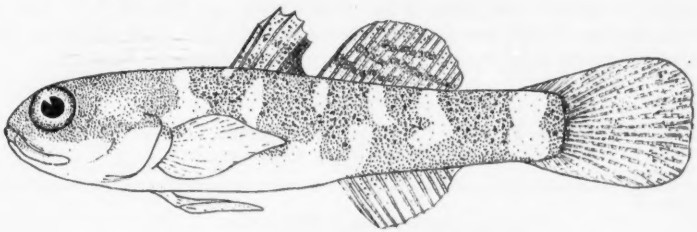

Fig. 3. Juvenile 35 mm. in total length.

On the eighth day many of the embryos have become slightly longer than their surrounding membrane so they must curve the tip of the tail. An air-bladder is distinguishable just above the yolk. The heart has commenced to beat. The eye has become pigmented and melanophores are present along the posterior half of the ventral and dorsal body margins, but not on the fin fold (Fig. 10).

It was expected that the eggs would hatch within the next 48 hours but in this critical period the embryos died. The eggs had been kept at an average temperature of 18° C. At this temperature it is safe to assume that the period of development prior to hatching is 10 to 12 days.

Young

Young of *Gillichthys* were collected in the sloughs of Mission Bay, San Diego. The smallest (Fig. 2), 11.5 mm. in total length, has the yolk sac absorbed. The chromatophore pattern is much the same as that of the eight-day embryo. There are large stellate melanophores along the mid-dorsal and ventral lines. Just anterior to the anal fin, the ventral melanophores leave the mid-line and extend dorsally in a sloping row to the dorsal base of the pectorals. There are a few melanophores on the posterior part of the lateral mid-line and a number of smaller melanophores about the muzzle and above the eye.

At this and at somewhat more advanced stages the young of *Gillichthys mirabilis* look strikingly different from the adult. They are small-mouthed and large-eyed, whereas the adults have inordinately long jaws and very small eyes. The coloration is also different. Such young were figured by Eigenmann (1892: pl. 15, fig. 12) and were described by Hubbs (1921: 1–3) as *Aprolepis barbarae*. The young figured by Eigenmann is intermediate between my Figures 2 and 3.

Larger juveniles (Fig. 3) develop the typical mottled design of the adult. A characteristic color pattern of the young is the dark blotch on the posterior portion of the first dorsal fin. The maxillaries commence to elongate directly after hatching. By the time the fish are 35 mm. long the upper jaw extends to the posterior margin of the eye. In some of the larger fish, 18 to 20 cm., the maxillaries extend to the base of the pectorals.

Spawning Period

To obtain data on the natural time for the spawning of *Gillichthys*, we started netting for the young in San Diego River and Mission Bay. Also, for examination of their gonads, adults were brought from bait dealers at two-week intervals, from the last of February to the middle of July.

Table I

Size Frequencies of Young of *Gillichthys mirabilis* Seined in 1946 in San Diego River and Mission Bay, California

Date of Collection	Size Groups in Millimeters										
	6–10	11–15	16–20	21–25	26–30	31–35	36–40	41–45	46–50	51–55	56–60
February 28	...	6	12	1	...	...	...	...	...	...	...
March 2	...	3	1	2	...	...	...	...	...	...	...
April 6	...	1	35	22	38	15	3	...	...	...	...
April 21	1	42	40	151	245	143	6	5	4	1	...
May 5	1	1	1	1	3	40	45	15	8	4	1
May 18	...	...	...	2	...	...	1	...	...	2	1
June 20	...	...	...	...	...	...	...	...	...	...	...

Young were caught each time, but newly hatched juveniles were taken only from February to the last of May. Size frequency distribution of the young (Table I) indicates that the heaviest spawning took place in February, March and April. Since juveniles up to 25 mm. long were netted on the

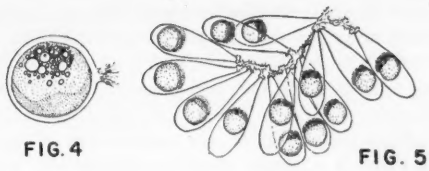

FIG. 4

FIG. 5

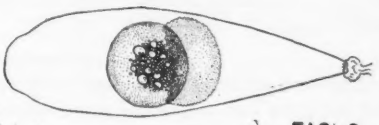

FIG. 6

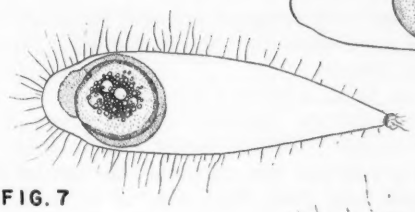

FIG. 7

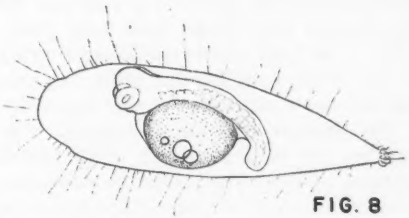

FIG. 8

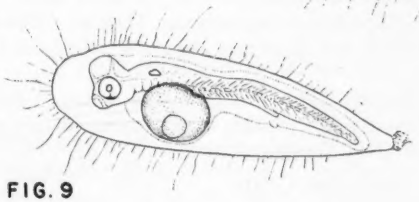

FIG. 9

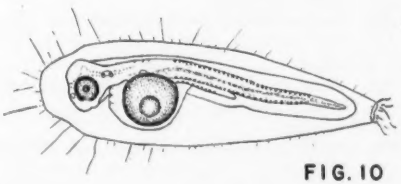

FIG. 10

Figs. 4–10. Eggs and embryos of *Gillichthys mirabilis*

Fig. 4. Mature unfertilized egg. Fig. 5. Portion of the egg mass showing the attachment by adhesive threads. Fig. 6. First day of development. The blastoderm forms a cap over the yolk toward the attached pole. Fig. 7. Second day of development. The anlage of the head forms a swelling opposite to the attached pole. Fig. 8. Four-day embryo. Fig. 9. Six-day embryo. Auditory placode apparent above the anterior portion of the yolk. Fig. 10. Eight-day embryo. The air-bladder lies just above the yolk sac. Chromatophores are developed and the eye is pigmented.

first collection, on February 28, spawning must have commenced somewhat earlier, probably in January.

The condition of the ovaries of adult females procured during the same months conforms fairly well with the data obtained from examination of the young. For February and March, one female in five had spawned, two had mature ova and two immature ova. In April half had spawned, and by June six in seven were through spawning. All but a very few examined in July had depleted ovaries. Since the visible eggs in the ovaries are of equal maturity it is probable that there is a single annual spawning or, under favorable conditions, possibly more than one spawning in the year but some months apart.

Summary

The mudsucker or long-jawed goby is one of the most important baits used for fresh and salt water sports fishing in southern California. Its life history has not been previously described.

A male established territory in a corner of a laboratory aquarium and constructed a redd in the gravel bottom. Intruders into his portion of the tank were driven off with an unusual combative display. The defender and the intruder rapidly darkened in color and then approached one another until they brought into contact their huge jaws, which were extended at right angles to the body. After one or more such performances, during which the defender pushed the intruder away, the latter deserted the nest area. The male selected a mate and the pair spawned.

The fertilized eggs are club-shaped with adhesive threads on one end. They are laid in large masses which resemble hundreds of minute yellow grapes on a stem. The period of development is from 10 to 12 days. The young of *Gillichthys* are unlike the adults in appearance. They are differently pigmented and are small-mouthed and large-eyed, whereas the adults have very long jaws and small eyes.

The spawning period in the San Diego area (determined from collected young and examination of adult gonads) extends from January to July with the height of spawning in February, March and April.

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SCRIPPS INSTITUTION OF OCEANOGRAPHY, LA JOLLA, CALIFORNIA.

A Shallow-Water Diving Rig[1]

By WILLIAM F. SIGLER and TOM MOEN [2]

EXPLORATION of underwater phenomena has been virtually denied the aquatic biologist because of inability to move freely and to observe beneath the surface of the water. Conventional diving rigs, such as the diving bell and the diving suit, are expensive and do not permit free movement. There is need for an inexpensive type of diving gear that permits the diver to move easily and without disturbing the bottom.

To meet this obligation, equipment used by the U.S. Navy during World War II for shallow diving has been refined and tested for use in fisheries investigation in Iowa (Figures 1 and 2). A light rubber face mask which permits the diver to swim at any level, has eliminated many of the operational disadvantages of other types of more expensive apparatus. The only problem involved in converting this outfit to civilian use was a satisfactory source of air. This was solved very nicely with an air compressor driven by a small gasoline motor.

1 Journal paper No. J-1402 of the Iowa Agricultural Experiment Station, Project No. 764 and Industrial Science Research Institute Project No. 45. The Fish and Wildlife Service (U. S. Department of the Interior), Iowa State College, Iowa State Conservation Commission and the Wildlife Management Institute cooperating.

2 The authors wish to thank Mr. Glenn Powers and Mr. Otto Koch of the Iowa State Conservation Commission for aid and advice, and Drs. Thos. G. Scott and Geo. O. Hendrickson of the Iowa Cooperative Wildlife Research Unit for assistance in preparation of the manuscript.

The pieces of tackle used to assemble this diving rig were: A U.S. Navy Mark III gas mask, 50 feet of air hose, an air compressor, a portable gasoline motor, and an air storage tank. The two air inlets of the mask were connected to the air hose with a T-fitting assembled from materials acquired from a garage and from a plumbing shop. One of the valves used to regulate the flow of air to the mask was located in the vertical arm of the T-fitting and the other valve was on the air tank. A 45-foot length of air hose, similar to that used by garages to inflate automobile tires, connected the mask to the air storage tank. The tank, taken from a hot water heater, had a capacity of 2.36 cubic feet. It was equipped with control valves at the air outlet and the air inlet, and with a pressure gauge. A 6-foot hose attached the compressor to the air tank. The compressor, taken from a small paint spraying outfit, was designed to maintain 40 pounds pressure. The power was supplied by a Briggs-Stratton washing machine motor. The diameters of the compressor and motor pulleys were four inches and two and three-fourths inches, respectively. A three-eighths inch V-belt was used for the drive.

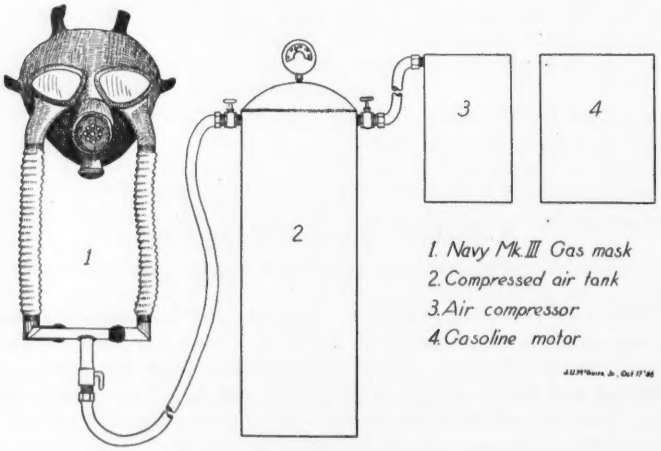

Fig. 1. Diagrammatic arrangement of parts for a shallow-water diving rig.

The mask covers the face back to the ears. During a dive, the additional pressure created by exhaling causes the air to bubble out around the edge of the mask. When the mask is properly adjusted, water rarely leaks in. Water inside the mask can be expelled with the exhale by the diver lying in a horizontal position, face up, and making a slight opening under the edge of the mask with a finger. The U.S. Navy Mark III gas mask has proven quite satisfactory for this work and is usually inexpensively acquired. It has two air inlets, one below each eye to prevent fogging. Any gas mask in good condition would probably be satisfactory. A gas mask has the disadvantage of limiting the vision more than some of the commercial masks specifically designed for diving.

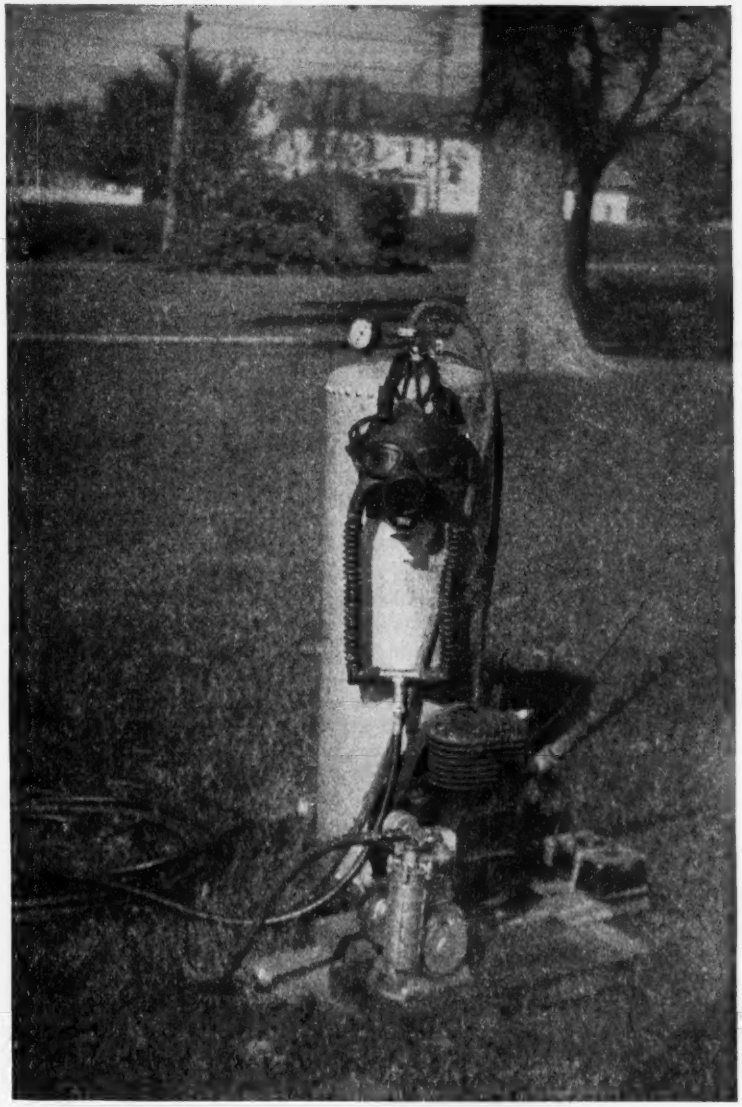

Fig. 2. The assembled diving rig ready for operation.

The length of air hose needed is determined by the depth of the dive and extent of travel away from the source of air. Ordinarily a length of hose two

and one-half to three times the depth of the dive is sufficient. A short piece of hose is required to connect the compressor to the pressure tank. The type of hose described here was strong and durable but unnecessarily heavy. Any hose that will stand the pressure developed in the air storage tank is satisfactory.

In order to make a quick descent, and to work horizontally near the bottom, the diver needs a compact, easily detached and weighted belt, which can be made from an Army 30 caliber ammunition belt. The bandoleer pockets, fitted with lead bars, provide an easy method of varying the weight of the belt. The correct weight of the belt during a dive is determined by the operating depth, the position of the body and the weight of the diver. A 40-pound belt was satisfactory for a 180-pound diver at 15 feet of water.

Pressure on the ears, during operations at a depth of 15 feet or more, caused discomfort or even acute pain. Adequate ear protection was secured by using ear plugs overlaid with a wad of lamb's wool and covered with a tight fitting bathing cap.

Dives of more than 35 feet with this type of equipment are inadvisable except for the most experienced divers. The length of time that a diver should remain submerged is determined by the temperature of the water and the depth of the dive. About 30 minutes appears to be the maximum time that one should remain down in water 70 degrees F. or colder. The use of an air storage tank supplies the diver with a constant even flow of air and provides a reserve in case of motor or compressor trouble. It is not amiss for a diver to carry a heavy bladed knife if there is a possibility of fouling the lines, and it is imperative that he wear an attended life line.

At a depth of 25 feet dives of 20 minutes duration were completed without difficulty or discomfort. The pressure in the air storage tank was pumped to 40 pounds pressure before each dive. During descent, the air pressure in the tank dropped gradually until the force of the water on the mask held it steady. The number of pounds of pressure per square inch in the tank, at any given level, was approximately equal to the depth in feet at which the diver was operating. However, regardless of the depth of the dive, the pressure did not drop below what appeared to be the minimum diver consumption requirement of 12 pounds. The quality and fit of the mask largely determine whether or not the minimum pressure can be maintained. This factor can be tested by the diver without submerging.

A diving outfit, satisfactory for dives up to 30 minutes duration and to depths of 35 feet, can be assembled for a cost of between $35.00 and $70.00 depending on the source of materials. The use of a larger motor and a larger compressor was considered, but not tried. While the practicability of the equipment has been demonstrated, the operation of it is not fool-proof. It is wise for inexperienced persons to confine their initial efforts to swimming pools or small ponds, although relatively little experience is required to become moderately efficient with the equipment described. The practice of frequent underwater observation offers a valuable and interesting approach to many phases of freshwater biology.

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The Use of Minor Postglacial Drainage Connections by Fishes in Indiana [1]

By SHELBY D. GERKING

A DISTRIBUTIONAL study of the fishes of Indiana (Gerking, 1945) offered considerable evidence that minor postglacial connections between the Great Lakes and Mississippi drainages may have greatly influenced the northward dispersal of fishes by providing temporary pathways through otherwise impassable barriers. It has been known for some time that fishes used the major connections, i.e., the Chicago outlet and Maumee River, between these two drainages as they migrated northward during the ice retreat (Greene, 1935). Herman Wright (1932) traced the migration of certain freshwater snails through a minor glacial connection from the Kankakee-Iroquois drainage to the upper Tippecanoe River, but other forms of aquatic life have not been studied from this standpoint.

Indiana was partially covered by both the Illinoian and Wisconsin glaciers, whose limits have been described by various authors, more recently by Thornbury (1937). The Illinoian glacier covered all of Indiana except an area in the southern portion extending from the westernmost tip of the state upward to Bloomington and descending to the Ohio River at Jeffersonville. The Wisconsin glacier covered the northern two-thirds of the state with its southern boundary between the 39° and 40° parallels. The Huron-Erie lobe of the Wisconsin glacier retreated to the northeast and Lake Maumee, an early stage in the development of Lake Erie, was formed at its southern border. This lake extended into northeastern Indiana as far as Fort Wayne and its discharge was carried by the Maumee River to the Wabash River at Huntington. This connection between the present Great Lakes and Mississippi drainages existed for a considerable length of time and carried the bulk of the glacial water of the state. Melting ice from the Michigan lobe of the glacier formed the beginning of Lake Michigan and its outlet (Chicago outlet) discharged into the Illinois River. Another major connection between the two great drainage systems was thus established. Both of these major connections accepted glacial water for a long period of time, perhaps 50,000 years, and there is no doubt that they were used by fishes in their northward dispersal.

In addition to these major connections several minor ones existed in the northern part of the state. The Saginaw lobe, or middle lobe, of the Wisconsin glacier was first to retreat, and after the Michigan lobe had retreated far enough northward to allow westerly drainage, the upper Tippecanoe River was probably connected with the Kankakee and Iroquois rivers. Leverett (1915), who last worked on the glacial geology of that region, states that "from near Ora in Starke County there may have been a northwestward drainage to the Kankakee as well as a southwestward drainage to the Iroquois." Later in the development of this region the St. Joseph River was probably connected with the Kankakee drainage at South Bend (Leverett, 1915). These connections probably existed a much shorter time than the two major connections mentioned above and it was not known whether fishes actually used these minor connections as they moved northward during the ice retreat.

[1] Contribution from the Department of Zoology, Indiana University, number 361.

There is also a possibility that other connections between the Great Lakes and Mississippi drainages might once have existed, although they have not been confirmed geologically. Only a few hundred yards separate the two great drainage systems at some places in the upper Tippecanoe region.

Many of Indiana's fishes are so widespread in both the Great Lakes and Mississippi drainages that their migratory routes are obscure; these species probably used all, or at least most, of the available pathways. Examples of these species are *Catostomus c. commersonnii,* the white sucker, *Notropis cornutus,* the common shiner, and *Ameiurus n. natalis,* the yellow bullhead. Other common fishes, such as the bluegill and the largemouth bass, have been so widely introduced that their original distribution in the state is obscure. However, there are a few species whose distribution in the state indicates that they used the minor glacial connections in their northward migration. *Notropis chalybaeus,* the ironcolor shiner, is the best example. The middle-western specimens of this minnow, which were formerly considered a form of *Notropis xaenocephalus,* have recently been recognized as a distinct species by Dr. Carl L. Hubbs. The ironcolor shiner ranges from the Delaware River southward on the east coast, along the border gulf states and up the Mississippi valley into Illinois, Indiana and Michigan. It is found in the Kankakee, Iroquois, Tippecanoe and St. Joseph river systems of Indiana (Fig. 1). The

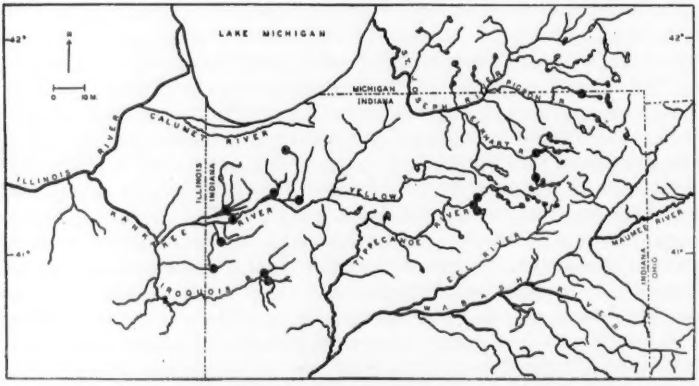

Fig. 1. The Distribution of *Notropis chalybaeus* in northern Indiana.

minnow definitely prefers slow moving creeks and ditches which have abundant vegetation. Leverett (1915) cites good evidence that parts of the Kankakee and upper Tippecanoe river systems were ponded in early postglacial times and it is also established that the St. Joseph system north of South Bend was once a part of the early postglacial Lake Dowagiac. Since stagnant waters were apparently present at an early date, it is quite possible that abundant aquatic vegetation could have become established in the ponded areas and connecting streams, thus meeting the habitat requirements of *Notropis chalybaeus.*

In its northward migration, the ironcolor shiner undoubtedly moved up

the Illinois River to the Kankakee and Iroquois, where it spread into the upper Tippecanoe River by way of a glacial connection between these drainages. Another route to the upper Tippecanoe existed by way of the Wabash River where proper habitats for the minnow do occur, but apparently this path was not used by the ironcolor shiner, since it has not been found in any Wabash tributary except the upper Tippecanoe River. To reach the St. Joseph drainage, the minnow might have used the connection which once joined the Kankakee and St. Joseph rivers at South Bend. Also, it could have passed through the Chicago outlet into Lake Michigan where it spread along the shoreline until it found the mouth of the St. Joseph River. Both of these routes were possibly migratory channels, although the former seems the most likely.

There are other species whose distributional patterns are similar to that of *Notropis chalybaeus*. The western banded killifish, *Fundulus diaphanus menona,* is found in the Kankakee and Calumet river systems, both tributary to the Illinois River, in addition to the upper Tippecanoe and St. Joseph drainages. The banded killifish is an inhabitant of lake shores and has never been recorded from streams in Indiana. Meek and Hildebrand (1910) reported the banded killifish from Lake Michigan so there is little doubt that it used the Chicago outlet as it moved northward. *Erimyzon sucetta kennerlii,* the western lake chubsucker, is another lake-inhabiting species which could have used the same glacial connections as *Notropis chalybaeus*. It has been taken in lakes and a few weedy streams in the Kankakee, St. Joseph and upper Tippecanoe systems. *Notropis hudsonius,* the spottail shiner, is also a lake form found in the Kankakee, Tippecanoe and St. Joseph drainages which could have gained entrance to its present localities by way of the minor glacial connections.

The distribution of *Notropis heterodon,* the blackchin shiner, resembles that of the above species with one exception. In addition to being found in the Tippecanoe, St. Joseph and Kankakee drainages, it also occurs in Hamilton Lake, Steuben County, which drains into the Maumee River. Since there is no evidence that this minnow entered Indiana by way of the Wabash River, it seems possible that a connection might have existed between the Lake Erie and Lake Michigan drainages in this region. Less than a mile separates the Hamilton Lake drainage from a tributary of Pigeon Creek which flows into the St. Joseph River.

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Notes on Two Darters of the Genus *Boleosoma* [1]

By Frederick L. Stone

TWO currently recognized subspecies of darters, *Boleosoma nigrum nigrum* (Storer) and *B. nigrum olmstedi* (Rafinesque) have geographical ranges that overlap along the south shores of Lake Ontario (Hubbs and Lagler, 1941) and both forms are reported in the Allegheny-Chemung drainage (Greeley, 1938). The University of Rochester Museum of Natural History collections include specimens identified as the western form, *B. nigrum nigrum,* from as far east as Mudge Creek, Wayne County, and others identified as the eastern form, *B. nigrum olmstedi,* from as far west as Otter Creek, Orleans County.

That the two groups should continue to be recognized as subspecies of a single species is somewhat dubious. Their ranges are compatible with their present status, but clear evidence of intergradation in their zone of overlap is lacking. The diagnostic key characters listed by Hubbs and Lagler (1941) for *B. nigrum nigrum* are: dorsal soft rays usually 11 to 13, and nape, breast, and cheeks scaleless; while for *B. nigrum olmstedi* they are: dorsal soft rays usually 13 to 15, and cheeks scaly. By these characters, (1) specimens taken within the zone of range overlap can be rather readily assigned without ambiguity to one or the other subspecies, and (2) collections from a single stream or even a single sample include both forms. The latter situation exists in Irondequoit Creek, Buttonwood Creek, Salmon Creek, and North Creek, Monroe County, New York (see Table I).

In considering these facts it was felt that the intergradation to be expected of subspecies from the zone of range overlap might appear if more characters were studied. Furthermore, the separation of two such forms is somewhat subjective, in part because they have one number of soft dorsal fin-rays in common, namely 13. This is roughly the number one would expect in intergrades. But a collector might understandably assign any given 13-ray specimen to one or the other subspecies, on the basis of scutellation. This procedure would ignore the fact that intergrades might well resemble one subspecies in one character and be intermediate between the two subspecies in other characters. It seemed desirable, therefore, to re-investigate these two forms inside and outside their zone of range overlap with respect to characters in addition to those given by Hubbs and Lagler (1941).

It has been customary, where a character complex has been studied, to establish the taxonomy of closely related forms by treating each character difference separately. Ginsburg (1938) and Hubbs and Perlmutter (1942) have demonstrated pictorial and statistical representation of such differences. Wherever a taxonomic judgment is to be based on a complex of characters, the problem immediately arises as to how the evidence from separate character differences can best be combined into one conclusive judgment. There have been three general approaches: (1) the worker examines the chosen characters of each specimen and arrives at a largely subjective decision concerning the material; (2) the worker examines a series of meristic characters,

1 The author wishes to express his appreciation to Dr. D. R. Charles for aid in the statistical technique employed.

performs some statistical analysis of each separate character and finally evaluates these results relative to each other (here the final evaluation is subjective with respect to the worker); (3) rarely, the results of the statistical analysis of separate meristic characters have been combined into a single objectively obtained basis for judgment.

TABLE I

SOFT DORSAL FIN RAY COUNTS AND SCUTELLATION OF TWO POPULATIONS EACH OF *Boleosoma nigrum nigrum* AND *olmstedi*

Subspecies and Locations	Soft Dorsal Fin Ray Counts								Cheek Scaled		Breast Scaled		Nape Scaled		Any One or More Areas Scaled	
	10	11	12	13	14	15	16	17	Yes	No	Yes	No	Yes	No	Yes	No
24 specimens *B. n. nigrum* from Michigan and Chau. Co., N. Y.	1	2	8	12	1				0	24	0	24	0	24	0	24
36 specimens *B. n. nigrum* from zone of range overlap		5	15	16					0	36	0	36	0	36	0	36
183 specimens *B. n. olmstedi* from zone of range overlap			1	18	76	16	1		183	0	168	15	176	7	183	0
203 specimens *B. n. olmstedi* from Ulster, Sull., Del., Orange, Col., Otsego, Broome, Chen. counties of eastern N.Y.		1	3	30	99	62	7	1	175	28	110	93	152	51	183	20

A technique for combining multiple measurements in taxonomic problems has been proposed by Fisher (1936), and will be applied here to new data bearing on the taxonomic status of *Boleosoma nigrum nigrum* and *B. nigrum olmstedi*. This method involves the use of discriminant functions. That is, each measurement is multiplied by a factor and the products of measurements and factors are added, yielding a single specimen index. The factors used are those which give the least possible overlap of indices (misidentification) between the groups to be compared. The method for obtaining them is shown by Mather (1943).

Fisher's method has been applied to the four populations shown in Table I. For the classification of these populations four characters were chosen: number of lateral line scales, number of scales below the lateral line, number of rays in second dorsal fin, and the scutellation (or lack of it) of either nape, cheek, or breast. In the latter character, scutellation of either one of the areas was entered as "1," while the lack of scutellation of either area was entered as "O." In this way the important data concerning scutellation were

put in a form compatible with the requirements of the statistical treatment.

Applying Fisher's method to the four chosen characters (only for areas outside the zone of range overlap) gives the following index, as defined above.

Specimen index equals
10.64 x (scutellation value for specimen)
+ 1.911 x (number of soft dorsal rays)
+ 0.2154 x (number of lateral line scales)
— 0.3389 x (number of scales below lateral line)

Such an index has been calculated for each specimen from eastern New York, from western New York and Michigan, and from the zone of range overlap. The results are shown as histograms in Figure 1, while the mean indices for the four populations are shown in Table II. The essential relations are so clearly shown by the histograms as scarcely to require elaborate statistical analysis. Thus, as the lower two parts of Figure 1 indicate, the difference between the mean indices of *B. nigrum nigrum* and *B. nigrum olmstedi* in the area outside the zone of range overlap is 251 times its standard error, which is itself ± 0.052. This is in spite of the fact that the *B. nigrum olmstedi* population has a component overlapping with that of *B. nigrum nigrum*.

TABLE II

	Mean Index within zone of range overlap	Mean Index outside zone of range overlap
Boleosoma nigrum nigrum	30.71	31.26
Boleosoma nigrum olmstedi	46.37	44.31

From Table II it can be seen that the mean indices of the two forms from outside the zone of range overlap are closer to each other than are the indices for the two forms within their zone of range overlap. Thus the unusual condition exists where two subspecies, widely separated geographically, seem to be less distinct from each other than are the same two subspecies when occupying common territory. It may be explained by the fact that in the forms from eastern New York were included one group from Kenoza Lake, Sullivan County. These particular specimens had the scutellation of *nigrum* but their other characters are those of *olmstedi*. Their mean index was 34.80 thus lowering the mean index of the eastern *olmstedi* group from 45.01 to the reported value of 44.31. Notwithstanding these facts it is felt that intergradation can be disregarded, for *nigrum* has not been reported from this drainage (Greeley, 1936). It may be presumed, however, that gene fixation resulting in the loss of scutellation has taken place in this small isolated population and not in the populations around it. The random fixation of genes in such small populations counter to possible selection pressure and counter to the evolutionary changes in similar but larger populations is a recognized phenomenon (Dobzhansky, 1941).

The above data indicate that these forms are as divergent from each other in their common distributional areas as they are in the extremes of their ranges. This casts doubt upon the validity of the nomenclature as applied to them, for in fact they do not appear to be each a subspecies of *nigrum*. When

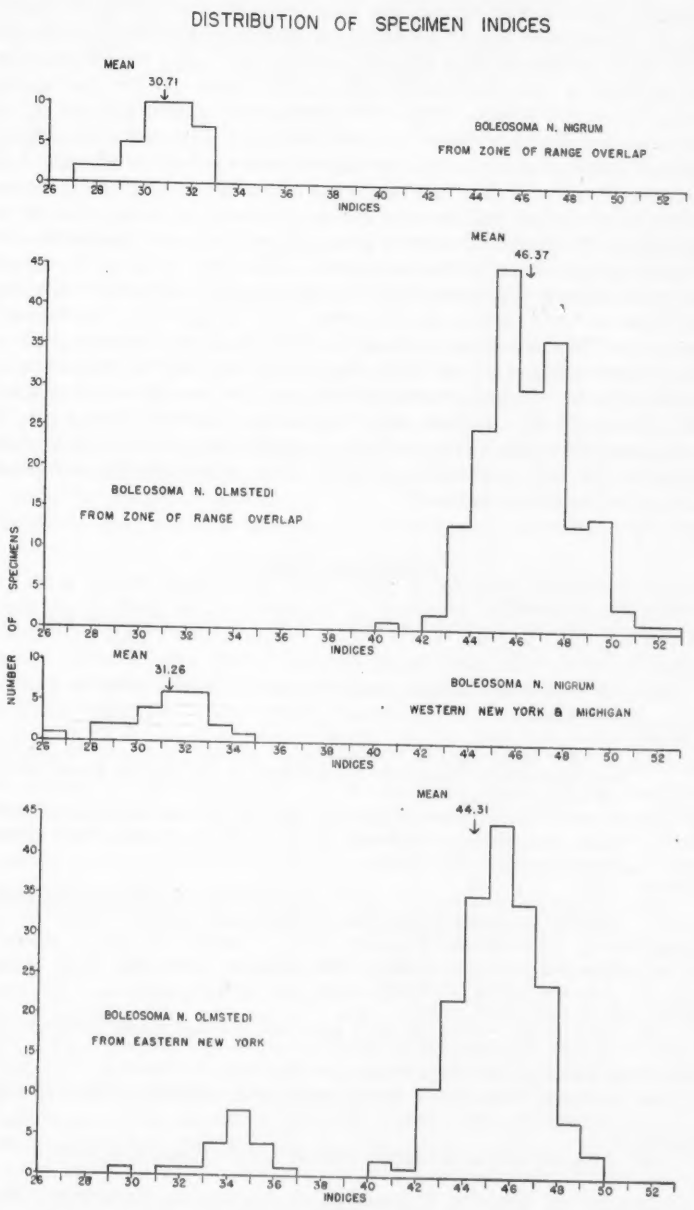
DISTRIBUTION OF SPECIMEN INDICES
MEAN
30.71
BOLEOSOMA N. NIGRUM
FROM ZONE OF RANGE OVERLAP
INDICES
MEAN
46.37
BOLEOSOMA N. OLMSTEDI
FROM ZONE OF RANGE OVERLAP
NUMBER OF SPECIMENS
INDICES
MEAN
31.26
BOLEOSOMA N. NIGRUM
WESTERN NEW YORK & MICHIGAN
INDICES
MEAN
44.31
BOLEOSOMA N. OLMSTEDI
FROM EASTERN NEW YORK
INDICES

Fig. 1

considered only in the light of the data presented, the two forms treated appear to be distinct and of specific status. However, their relationships with other forms as reported from different parts of their ranges suggest that they are members of two intergrading series of subspecies (Hubbs and Lagler, 1941; Hubbs and Greene, 1935). The geographical pattern covered by the *nigrum* series extends southward in the Mississippi Valley west of the Appalachian Mountains, while that of the *olmstedi* series extends southward along the Atlantic coast to the Carolinas. Physical conditions during Pleistocene glaciation may very well have caused the predecessors from which *B. n. nigrum* and *B. n. olmstedi* arose to have been split into two populations isolated from each other by the Appalachian Mountains. During the tens of thousands of years that these forms were isolated from each other, they may well have acquired genetic dissimilarities which would make interbreeding impossible. This separation would not, however, cause any cessation of north-south interbreeding along the Mississippi Valley or along the Atlantic coast. Thereafter when this glacier retreated and the two now distinct populations came to occupy this common area, they maintained their distinctness. It now remains for extensive field collection and searching statistical analysis to determine the true relationships of these series of intergrading subspecies throughout the areas mentioned.

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The Early Life History of the Bridled Shiner, *Notropis bifrenatus* (Cope) [1]

By Robert W. Harrington, Jr.

Introduction

During the course of observations on the hitherto unknown breeding behavior of the bridled shiner, *Notropis bifrenatus*, the author obtained fertile eggs readily by artificial means. The brief incubation period, less than three days, rather long spawning period, roughly from the last week of May to mid-July, and small maximum size of this species, less than 2½ inches in total length, suggest its possible value as a subject for the experimentalist. An account of the breeding behavior and life cycle of this species will appear elsewhere.

The known range of *Notropis bifrenatus* extends through the Atlantic coastal drainage from southern Maine and New Hampshire south to the Potomac River system of Virginia and westward through Lake Champlain, the St. Lawrence River and Lake Ontario drainage (Hubbs and Lagler, 1941: 60). It inhabits small ponds and large lakes, small streams and large rivers, but only the shallows with still or slowly flowing water. In streams, it is restricted usually to the lower portions as it is a weak swimmer. Generally found over mud, silt, or detritus, it prefers moderate to abundant vegetation.

Material and Methods

From gravid females and from males in breeding coloration collected June 18–19, 1946, in the backwater of the Oyster River at Durham, New Hampshire, eggs and milt were stripped into finger bowls filled with river water. Males ranging from 25-32 mm. in standard length were employed, milt from even the smallest being effective. One female was only 26 mm. in standard length; the others ranged from 31-32 mm. in standard length. Eggs from all but the smallest were rendered fertile. This specimen, although noticeably gravid, apparently lacked fully matured eggs. The finger bowls were placed on the stage of a dissecting microscope, where the developmental stages were observed. When not under observation, they were covered with fine-meshed gauze held on by a rubber band to prevent the escape of free-swimming larvae, and immersed in the water of an 80-gallon aquarium, which maintained a mean temperature of 75°F.

Although mortality was high, five separate batches of eggs were carried through to the free-swimming larval stage, and members of one batch, released in the aquarium, continued to develop in good condition six weeks after hatching when observations were arbitrarily terminated. The ripe fish, which had been collected between 7 and 9 A.M., were stripped not later than 10:30 the same morning. Several attempts to obtain fertile eggs in the afternoon were unsuccessful although large specimens were stripped: eggs were obtained only with difficulty and were mostly undersized, although subsequent examination of the ovaries of the fish concerned revealed an abundance of sub-maximal-sized eggs. Possibly the females employed had laid their current quota of eggs earlier in the day or on the previous day. In this connec-

[1] Abstracted from a doctoral dissertation prepared under the direction of Professors A. H. Wright and E. C. Raney of Cornell University.

tion, it should be mentioned that a battery jar containing adults collected one morning was overlooked until late that afternoon, when fertile eggs were found adhering to the bottom in considerable numbers, having been spawned in the jar.

Structure of the Ripe Unfertilized Egg

The egg of *Notropis bifrenatus* is a perfect sphere. Before imbibition of water, it is approximately 1 mm. in diameter. Afterwards, the zona radiata becomes separated from the egg proper by a water-filled space about 0.25 mm. wide giving the egg as a whole an outer diameter of 1.5 mm. The zona radiata is striated by meridional lines converging at and running down into the depression of the micropyle. In this state, the egg proper is milky whitish and the space between it and the zona radiata is a pearly gray. The egg is demersal and devoid of oil globules, and sinks at the rate of one foot in 58 seconds in water at 75°F. Sterile eggs are non-adhesive and some swell in five minutes.

Fertilization

The milt can be distinguished by the unaided eye only as a slight cloudiness at the anal papilla of the male. Seven minutes after eggs and sperm are mingled, a fertilization cone is formed. It arises from the egg surface adjacent to the micropyle, stretches across the intervening space and, tapering into a column three times as long as broad, joins the micropyle, breaks off within 30 seconds of the time it first appears, then recedes into the surface of the egg. The periphery of the egg adjacent to the micropyle clears at once to a translucent, pale, golden yellow, contrasting with the granular opacity of the yolk beneath it. Fertile eggs adhere to the bottoms of dishes, and can be distinguished by this attribute and by the pale golden translucence which they acquire. Once adherent to the surface, they remain so, and it is hard to dislodge them without puncturing the zona radiata. Once removed, however, they can be rolled about at will without damage, and are no longer adhesive. Some were dislodged before the first cleavage had taken place. Apparently, the zona radiata becomes progressively tougher as it becomes water-hardened, since a larger proportion of later stages were dislodged without mishap.

Seventeen minutes after fertilization, the egg is somewhat aspherical, being greater in equatorial girth, and is surmounted by a prominent germinal disc (Fig. 1, A). The disc is pale yellowish, and is more opaque than the yolk in general, which is a transparent, pale, golden yellow except immediately beneath the disc, where it is very opaque. From this opaque region, semi-opaque streaks run down into the otherwise pellucid yolk-mass.

Cleavage

Segmentation is meroblastic and extremely discoidal.

1st stage: 1 hour and 10 minutes after fertilization (Fig. 1, B). Fifty-five minutes after fertilization, a depression appears on the surface of the elongated germinal disc; gradually extending inwards, it cuts at right angles to the longer axis. In 15 minutes the first cleavage is completed.

2nd stage: 1 hour and 14 minutes after fertilization (Fig. 1, C). The second cleavage takes place at right angles to the first after the elongation of the shorter axis of the first two blastomeres. The semi-opaque streaks men-

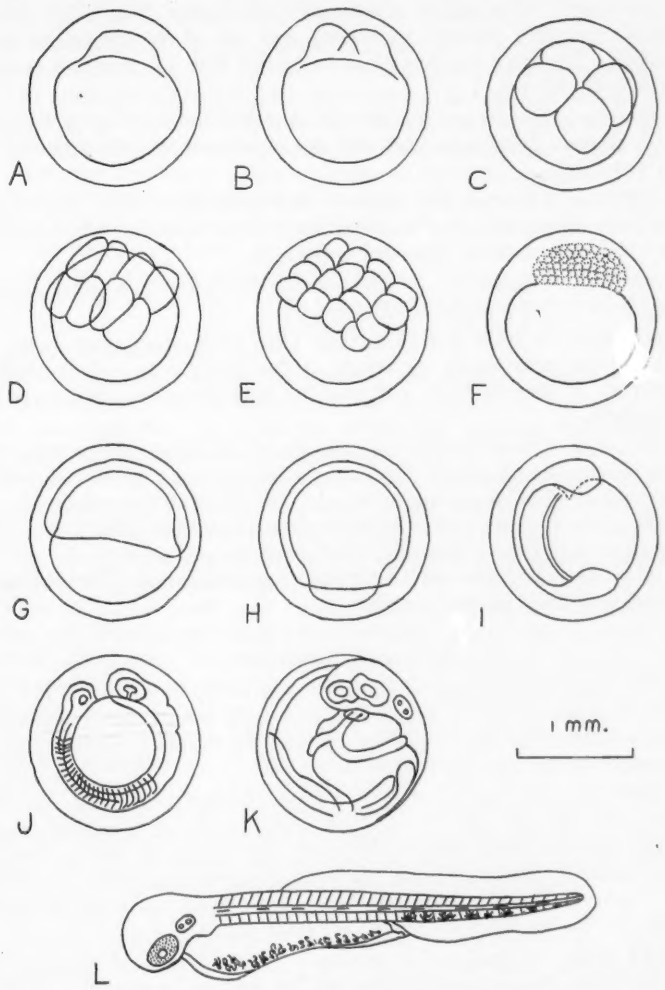

Fig. 1. Early development of *Notropis bifrenatus*, drawn from life

A. Egg seventeen minutes after fertilization. B. One hour and ten minutes after fertilization. C. One hour and fourteen minutes after fertilization. D. One hour and forty-two minutes after fertilization. E. Two hours and thirteen minutes after fertilization. F. Three hours and thirty-five minutes after fertilization. G. Eight hours and twenty minutes after fertilization. H. Nine hours and forty minutes after fertilization. I. Fifteen hours and forty minutes after fertilization. J. Twenty-three hours and ten minutes after fertilization. K. Fifty-six hours and twenty-five minutes after fertilization (twenty minutes before hatching). L. Fifty-six hours and forty-five minutes after fertilization (newly hatched larva, 4.1 mm. in standard length).

tioned above have disappeared, leaving a homogeneously translucent yolk-mass.

3rd stage: 1 hour and 42 minutes after fertilization (Fig. 1, D). As the time for the third cleavage approaches, one axis of the blastoderm again elongates. The third cleavage plane is parallel with the first and at right angles to the second.

4th stage: 2 hours and 13 minutes after fertilization (Fig. 1, E). The fourth cleavage plane is parallel with the second and at right angles to the first and third.

5th stage: 2 hours and 25 minutes after fertilization. This stage differs little from the preceding one in appearance, but a horizontal furrow divides every blastomere into an upper and lower half.

6th stage: 2 hours and 28 minutes after fertilization. Another division takes place, but further details are obscure.

7th stage: 3 hours and 35 minutes after fertilization (Fig. 1, F). A mulberry-like mass stands out clearly at the animal pole, covering only a small part of the yolk-mass, and resulting from the active division of the blastomeres.

8th stage: 8 hours and 20 minutes after fertilization (Fig. 1, G). The blastomeres are much smaller than those in the previous stage, and cannot be distinguished. The blastoderm extends to the equator of the yolk-sac.

9th stage: 9 hours and 40 minutes after fertilization (Fig. 1, H). The blastoderm covers more than three-quarters of the yolk-sac.

10th stage: 12 hours and 10 minutes after fertilization. The yolk-sac is completely invested by the blastoderm.

Formation of Embryo

11th stage: 15 hours and 40 minutes after fertilization (Fig. 1, I). The rudiment of the embryo is formed as a thickening around the circumference of the yolk-sac. The keel of the epiblast and the shallow medullary groove, mentioned by Balfour (1881: 58), can be seen.

12th stage: 23 hours and 10 minutes after fertilization (Fig. 1, J). The embryo has enlarged and is more differentiated. Optic invaginations are present; octocysts have not yet developed. The embryo is closely attached to the yolk-sac. Kupffer's vesicle has made its appearance at the caudal end of the embryo. Notochord and mesodermal somites are visible in the middle region, but are not differentiated in the caudal region.

13th stage: 28 hours and 15 minutes after fertilization. A large part of the tail is free, the gut is elongating, and the yolk-sac is noticeably reduced in size. In the otocyst, which has been present for some time, two otoliths, the asteriscus and sagitta, are developing. The heart is beating and the flow of blood can be seen.

14th stage: 32 hours and 20 minutes after fertilization. The circulation of blood is visible over the surface of the yolk-sac and between the eye and brain. The eye is becoming pigmented and has a lens. The tip of the tail extends beyond the otic capsules.

15th stage: 56 hours and 25 minutes after fertilization (Fig. 1, K). The fully-formed larva 20 minutes before hatching is depicted.

Larval and Post-Larval Stages

Although most of the eggs hatched in 2 days and 9 hours after fertilization, one batch hatched in 2 days and 23 hours. Newly hatched larvae (Fig. 1, L) are transparent except for the pigmented iris, and measure only 4.1 mm. in total length. There is no pigmentation dorsally, but a delicate broken line of black pigment extends along each side foreshadowing the lateral band, which develops there later. There are scattered black chromatophores in the post-anal region along the junction of the body with the ventral fin-fold, and a diffuse network of chromatophores over the yolk-sac. Pectoral fin-buds are minute or may be lacking at the time of hatching. There is no sign of fin-rays, and the vacuolated notochord is straight. Having neither developed pectorals nor air-chamber, the larva (prolarva in the terminology of Hubbs, 1943: 260) lies on its side, occasionally darting off only to come to rest again on the bottom of the dish.

Eight hours after hatching, the prolarva has a slightly golden tinge, its pectoral fins have begun to differentiate, but are too tiny to have any functional value, and the heart is clearly visible from the side. Otherwise, in both appearance and behavior, it has changed little.

Two days after hatching, individuals which had been released into the aquarium were found adhering to the glass by their ventral sides, and were in a vertical position with heads facing upward. The pectoral fins were conspicuous, the yolk-sac inconspicuous, gills appeared to be present, and one of the prolarvae swam about continually.

Three days after hatching, a single, anterior, oval-shaped air-chamber is present, and the pectoral fins are well-developed. Small pigment spots dot the head and dorsum. An individual, placed in a watch-glass under a dissecting microscope, was seen to move its eyes alternately to right and to left. They were poorly co-ordinated, and one lagged behind the other.

A week later, they resemble neither prolarvae nor adults, and may be designated as postlarvae. A two-chambered air-bladder is now present, a posterior sausage-shaped chamber having been added to the oval anterior one. A continuous, though slender, black lateral band, and upturned notochord and developing caudal fin-rays characterize this stage, individuals of which swam about actively, and appeared to be feeding on constituents of plankton hauls introduced into the aquarium.

Two weeks after hatching, the ventral fins, which are the last to form, are not much developed, but in all essentials the young resemble the juveniles and adults of the species. The proportions are the same, and the black lateral band is now broad, although in the young, the pattern of pigment is more diffuse, the colors more drab, and the caudal spot proportionately larger than in the juveniles and adults. During the next two weeks, the fins become fully developed, and further pigmentation increases the details of resemblance.

In the sixth week after hatching, the young are perfect replicas of the adults, having acquired the same tone in coloration and all the characteristic movements of the latter.

Early Growth and Age

At intervals of approximately one, two, three, four, and six weeks, speci-

mens were removed from the aquarium and preserved. These specimens had hatched from eggs impregnated on June 18. They were reared at an average temperature of 75°F., and fed on plankton introduced periodically into the aquarium. Measurements taken on these specimens and arranged in Table I, although few in number, give some idea of the early growth rate. The

TABLE I

MEASUREMENTS ON 7 YOUNG BRIDLED SHINERS HATCHED AND REARED IN AN AQUARIUM

Date	Age in Days	Standard Length in Millimeters	Total Length in Millimeters
June 21	0	—	4.1
June 30	9	6.4	7.0
July 6	15	8.0	10.5
July 12	21	9.2	12.0
July 19	28	10.0	13.0
August 4	43	14.0	19.0
		8.5	10.2

range in size within a year-class of this species may be due in part to such unexplained size difference as that exhibited by the two 43-day-old specimens preserved on August 4.

The largest specimen of the first young discovered in the field in 1946, on July 2 and 5, was 10.0 mm. in standard length on July 5. It will be seen that the aquarium-reared specimen of the same length had acquired this length after an incubation period of somewhat less than 3 days and after 28 days as a free-swimming larva. Thus, counting back 31 days from July 5, an estimated fertilization date of June 5 is arrived at for this specimen, the largest of the first to be collected in 1946 and therefore presumably among the first to be spawned. As a date for some of the earliest spawning, June 5 accords rather well with observations in the field, for although the first tentative manifestations of breeding activity were seen on May 22, nothing regarded at the time as actual spawning occurred before June 7, when activity became greatly intensified.

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Subspecies and Breeding Behavior of the Cyprinid Fish *Notropis procne* (Cope)

By Edward C. Raney [1]

THE northern swallowtail shiner, *Notropis procne procne* (Cope), is a small species that apparently reaches its northern limit in Catherine Creek, the inlet of Seneca Lake, Lake Ontario drainage, New York. Its presence here has been attributed by Greeley (1928: 98) to a former canal connection with the Susquehanna system to the south. The use of the southern outlet of glacial Seneca Lake in the late Pleistocene is here considered an equally valid possible explanation. It is also found in the Delaware and Susquehanna of New York and ranges southward in Atlantic Coast streams to the James River in Virginia. It is represented from the Roanoke River system in Virginia southward to the Santee drainage in South Carolina by *Notropis procne longiceps* (Cope).

A detailed diagnosis of *procne* and related species has been prepared by Hubbs and Raney (1947). A key to the subspecies of *procne* appears below. Most of the differences are only average ones but the two usually can be separated by the summation of characters.

1a. Body deeper, body depth about equal to head length. Head deeper, depth at occiput when measured forward from posterior border of eye reaches beyond tip of snout. Body pigmentation generally darker; in breeding dress, body light straw color with light yellow fins; no dark pigment flecks laterad of deep seated melanophores along base of anal fin; dark lateral band wider anteriorly; darker on midline of back below posterior half of dorsal fin; more pigment on upper lip and snout as viewed from below. Snout averages shorter, slightly shorter than eye. Maxillary reaches to or beyond a vertical from front of eye. Mouth slightly sloping posteriorly but almost horizontal anteriorly, appearing slightly hooked in breeding adults, usually reaches a level between the orbit and the lower edge of the pupil. Mouth more inferior. Lower jaws somewhat pointed at symphysis. There is no difference in head length; it enters the standard length 4.0 times in both subspecies. *Notropis procne procne* (Cope), northern swallowtail shiner.

1b. Body more depressed, depth of body much less than head length. Head shallower, depth at occiput when measured forward into distance from posterior margin of eye reaches tip of snout. Body lighter colored; at breeding season body is yellow with orange in pectoral fins; some pigment flecks scattered laterad of anal fin; narrower dark lateral band; dark mark on midline of back below last half of dorsal fin varies but generally is not well developed; less pigment on upper lip and lower border of snout. Snout slightly longer, usually equal to or longer than eye. Maxillary not reaching to a vertical from front of eye. Mouth slopes slightly upward, does not level off anteriorly, and usually reaches the level of the lower margin of the pupil. Mouth less inferior. Lower jaws rounded at symphysis. *Notropis procne longiceps* (Cope), southern swallowtail shiner.

Northward the typical subspecies is most often found in upland streams and small rivers, and is generally classified as uncommon. It also has been taken in two lakes of the Susquehanna drainage, New York (Greeley, 1936:

[1] Grateful acknowledgement is made of a grant from the Trustee-Faculty Research Fund of Cornell University which made possible the field work. Thanks also goes to my ichthyological colleagues, Dr. Ernest A. Lachner and Robert D. Ross, who accompanied me on a collecting trip to Virginia and North Carolina during the period June 18 to 28, 1946.

82). To the south it becomes more abundant, especially in piedmont and mountain streams of Maryland, Virginia, and North Carolina. Its toleration of turbid water and sand bottom conditions, which usually exist in the piedmont streams, is good and here it is often found in large numbers. Its niche in the stream is usually in or near moderate riffles. A general avoidance of both the deeper pools and torrential rapids was noted. Most *procne* have been observed near the bottom in small schools.

Sexual Dimorphism

Sexual dimorphism is not pronounced in *procne*. The separation of the sexes would be difficult or impossible at other than the breeding season, since the slightly shorter pectoral and pelvic fins of the female are only average differences. The length of the first pectoral ray of the male when measured forward from the origin of the pectoral fin, reaches nearly to the front of the eye while in the female it goes to the middle of the eye. The pelvic fins of the male are longer; the longest ray reaches the orifice of the anal papilla posteriorly. In the female it barely reaches the anterior base of the protruding anal papilla and even in its extreme variation does not attain the orifice. The first ray of the anal fin of the male is much shorter than the first pectoral ray while in the female they are equal or subequal. The pectoral fins of the breeding male are further modified. They are thickened and bowed strongly outward at about the middle. The distal end is bent upward and inward. This modification along with the well developed breeding tubercles on the upper pectoral surface assists the male in grasping the female by a pectoral lock at spawning. In breeding condition preserved females can easily be recognized by the larger, rounded, and more protuberant anal papilla, the greater body depth due to the eggs, and by the relatively finer and fewer nuptial tubercles.

The tubercles are best developed on the top of the head of the male. They are moderately coarse, conical, and are rather evenly spaced over the top of the head with a somewhat more prominent ring about the upper eye. A similar type of tubercle is on the upper opercle with smaller ones on the lower opercle, cheek, lips, and underside of the head and breast. Relatively smaller ones also line the posterior margin of each scale. Those on the anterior sides and the back, in front of the dorsal fin, are larger than those on other scales. The upper surface only of the pectoral fin rays is covered by villiform tubercles which form a sandpaper-like surface. Fine tubercles also line the rays of both sides of the anal and dorsal fins and the upper surface of the ventral fins. The female possesses fewer and smaller tubercles on the head, body, and fins. Those on the head and body of the female are barely perceptible to the touch while in the male they are quite rough.

The lower lobe of the deeply notched caudal fin is rounded and shorter than the upper lobe. This is true only of spawning adults and is due to erosion as the breeding fish brush over the sand and fine gravel.

Living and freshly preserved males had a light yellow tinge to the pectoral, ventral, and dorsal fins. The body of both sexes was a light straw color. In water the males were darker and more active. Both sexes of the southern subspecies, *procne longiceps*, were much more yellow.

Breeding Behavior

Nothing has been written concerning the breeding habits of *Notropis procne*. Fowler (1909: 533) predicted that "it probably spawns in late spring or early summer." This contention was given added weight when females with well developed eggs were found in the upper Susquehanna drainage near Willseyville, Tioga County, New York, on July 10, 1938. The breeding behavior was seen on June 18, 1946, in Covington River, a tributary of the Rappahannock River, 4 miles south of Washington, Rappahannock County, Virginia. Here the Covington River was a medium sized mountain stream of rather short pools and long and usually moderately swift riffles which varied in width from 30 to 50 feet. The water was white and clear and the flow was approximately 50 cubic feet per second. Vegetation was sparse and mostly limited to algae. The bottom was largely rubble and gravel but occasionally there was considerable sand and silt, especially in the deeper pools. Fish were generally common and 13 species and one hybrid were collected. Other than *Notropis procne procne* the following were obtained: *Notropis analostanus* (Girard), many in high breeding color with well developed nuptial tubercles; *N. cornutus cornutus* (Mitchill), abundant, many adult males with some of the nuptial color still observable; *N. cornutus cornutus* × *Clinostomus vandoisulus*, 3 hybrids, one with some red along its sides; *Clinostomus vandoisulus* (Valenciennes), several adults which appeared to have finished spawning; *Nocomis micropogon* (Cope), common, one old nest of pebbles observed; *Exoglossum maxillingua* (LeSueur), common, one old nest about 12 inches in diameter made of small pebbles was seen at the head of a riffle; *Rhinichthys atratulus atratulus* (Hermann), abundant; *R. cataractae* (Valenciennes) subsp., several in riffles; *Catostomus commersonnii commersonnii* (Lacépède), common; *Hypentelium nigricans* (LeSueur), several; *Micropterus dolomieu dolomieu* Lacépède, one juvenile; *Lepomis auritus* (Linnaeus), one juvenile in riffle; *Boleosoma vexillare* Jordan, common in slower riffles, males in dark nuptial dress.

Breeding activity probably occurred throughout a rather shallow riffle about 8 to 12 inches deep since a large number of ripe specimens were taken there. However, it was definitely observed only in a second shallower channel at the side of the main riffle in water about 4 inches deep. The bottom was fine gravel and sand, the current moderate, and the water white and clear. Observations were made at a distance of only 6 to 10 feet rather late in the evening of a cloudy day. Air and water temperature was 78°F. at 8:30 P.M.

When first noted the behavior was markedly different from that of any cyprinid previously observed. A quick scoop over the spawning ground with a 10-foot seine yielded about 10 ripe *procne* of both sexes. Those that escaped commenced courtship and spawning activities immediately. From 15 to 25 adults remained in an area about 3 by 12 feet. The sand and fine gravel was clean, having been swept off by the almost constant and intense movements of the fish.

The sexes on the spawning grounds were about the same size, but the males could be distinguished immediately by their more active behavior and darker color. They occupied definite territories which they guarded from the intrusion of other males. Distances between males varied from about 5

inches on one downstream area, where 4 males were concentrated, to a span of 12 to 18 inches on other parts of the spawning grounds. The more widely separated males were much more successful in spawning partly because they spent less time fencing with other males. Most were apparently oblivious of our presence but one that held a territory near a small log was easily frightened and swam under it for shelter when disturbed. Incidentally, he did not often succeed in actually spawning.

The behavior pattern of an individual male follows. He assumed a position headed upstream somewhere within the cleared area which constituted the spawning ground and remained close to but not on the bottom. The main movement was a lateral one of about 3 inches with a quick return to the original position, and this was followed immediately by a similar movement to the opposite side. A diagram of his path resembles a laterally widened figure 8. The territory was approximately 6 by 6 inches. His movements to either side were greatly speeded upon the approach of another *procne*. Incidentally no other species was present in the immediate area to complicate the picture. When a male came within or near the guarded territory he was met by a head on rush. However, two males seldom appeared actually to collide. At times they edged each other aside but not with great vigor since in most cases they were of equal size. In the face of a determined rush an intruder usually quickly turned aside and beat a retreat. If he chose to stand his ground the two chased each other in a circular path for several seconds. Each male then returned to his original territory and resumed his active lateral movements. Occasionally several males attempted to invade a territory and a swirling group, their numbers increased by the addition of several late comers, moved rapidly over the spawning grounds. Within several seconds these groups scattered and each male returned to his place.

In contrast the females remained rather quietly below or laterad of the large spawning area. When ready to deposit eggs one came upstream and usually stopped slightly below and immediately downstream from a male. Sometimes she attempted to move up through a territory past a male. He quickly blocked her off from further upstream progress by throwing his body in her path but without appearing actually to strike her. The female then stopped and the male swam quickly from side to side, the tempo of his action greatly increased. With a female within 2 to 4 inches and downstream from the male, conditions were set up for the actual spawning act. He suddenly dropped downstream with his head still facing upstream and moved only slightly to either side. If the female held her position the male backed down beside her and inserted his pectoral fin underneath her head or breast and at the same moment threw his caudal peduncle across the posterior part of her body. This forced the female downward to the bottom, both vibrating vigorously for about a second, and the eggs were laid in the sand which was stirred up at this moment by the rapidly moving bodies. At the completion of the spawning act the female was not tossed upward as has been observed in some other minnows, but moved slowly downstream to the area below the spawning grounds.

Relatively few eggs of the total complement were laid at one spawning, and the same female would return to spawn again after a short period. Probably several days were required for the deposition of all the eggs of one

procne. The male immediately returned to his lateral movements in his territory and spawned again with another female within a few minutes.

The actual embrace at spawning was similar to that observed in several other cyprinids and described in detail for *Rhinichthys atratulus atratulus* by Traver (1929: 118). The other phases of courtship and territorial behavior are unique. Nothing is known of the breeding behavior of the other species of *Notropis* in the Atlantic drainage related to *procne*, namely *heterolepis, volucellus, bifrenatus* and *alborus* (see Hubbs and Raney, 1947). Indeed, few observations have appeared on the spawning habits of this large and widespread genus. The more pertinent papers are by Hubbs and Walker (1942: 101) on *Notropis longirostris* (Hay), Hankinson (1930: 73) on *Notropis spilopterus* (Cope); Greeley (1935: 94) and Stone (1941: 289) on *Notropis analostanus;* Hankinson (1932: 415) and Raney (1940a: 1; 1940b: 131) on *Notropis cornutus;* Hankinson (1932: 417), Pfeiffer (1942: 13), and Raney (1940c: 361) on *Notropis rubellus* (Agassiz); and Greeley and Greene (1931: 88) on *Notropis hudsonius hudsonius* (Clinton). The breeding behavior of *procne* is least like that of *longirostris* and *hudsonius* and probably approaches that of *cornutus* more than any of the other known species.

The correlation between the size reached by each of the sexes and the tendency to hold territories and to fight among the males is marked. Males are larger and have stronger and longer nuptial tubercles, especially on the head, in *cornutus, analostanus,* and *spilopterus*. All three species fight to hold territories. In *procne, longirostris,* and *hudsonius* the sexes reach equal lengths and have relatively small tubercles; *procne* attempts to hold a territory while *longirostris* does not. The former fights off males that attempt to intrude, while a male *longirostris* will battle males that attempt to follow his temporary mate. In *hudsonius* details of the behavior of the males at spawning are not known. Greeley and Greene (1931: 88) report that a large number of individuals mill about in a close packed group. The male *rubellus* are smaller than females and are covered with fine tubercles. There is relatively little fighting among males. They spawn in loosely knit groups which move about from one part of a riffle to another or utilize the nests of *Nocomis* or other species.

Age and Length

A collection made over the spawning area and in nearby riffles yielded 86 adult *procne* of which 48 were males and 38 females. A greater number of males is to be expected under the conditions where they are more active and engaged in guarding territories and is probably not an accurate indication of the actual sex ratio. An examination of the length frequency distribution of these 86 adults presented in Table 1 shows a pronounced bimodal condition. The scales revealed that the smaller adults, those ranging from 33 to 39 mm. standard length, were only one-year-old. The larger of the two modes, containing adults from 43 to 52 mm. long, consisted of two- and three-year-old specimens. The short life span indicated for *procne* is similar to that found in two other small species, *Notropis volucellus volucellus* (Cope) and *Notropis rubellus*. Black's (1945: 457) studies of *volucellus* from Shriner Lake, Indiana, revealed that a great preponderance of the individuals survive only

one winter and that few, if any, live through a third winter. In *rubellus* from the Alleghany River system of New York, Pfeiffer (1942: 13) found that some specimens were mature at one year. All spawn when two- and three-years-old and few reach a greater age.

TABLE I

LENGTH FREQUENCY DISTRIBUTION OF 86 ADULT *Notropis procne procne* TAKEN FROM A SPAWNING AREA AND NEARBY RIFFLES OF COVINGTON RIVER, RAPPAHANNOCK COUNTY, VIRGINIA, ON JUNE 18, 1946

Standard length in mm.	Frequency of 2- and 3-year age groups		Standard length in mm.	Frequency of the one-year age group	
	Male	Female		Male	Female
52	—	1	39	1	1
51	—	1	38	3	1
50	1	—	37	3	1
49	2	3	36	4	3
48	4	5	35	1	—
47	8	5	34	—	1
46	14	3	33	—	1
45	5	10			
44	2	—			
43	—	2			
No.	36	30		12	8
Mean	46.5	46.6		36.9	36.1

The sexes of *procne* attain the same length. An examination of several hundred specimens from a number of northeastern localities, now deposited in the Cornell University fish collection, revealed few specimens to be over 2 inches in standard length. Fowler (1909: 533) makes the general statement that *procne* averages about 2½ inches in length. If it is assumed that he referred to total length, our findings are in substantial agreement although our average is closer to 2¼ inches with an occasional large individual reaching nearly 3 inches. Greeley (1936: 76, plate 1) figures a female in color. This specimen, 2⅜ inches in total length, was collected in Oquaga Creek, New York.

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A New Pelobatid Frog from Fukien Province, China

By CLIFFORD H. POPE

IN 1931 I recorded 20 metamorphosing and immature frogs and 4 series of tadpoles from Ch'ungan Hsien, Fukien Province, China, collected by myself. All were tentatively identified as *Megophrys hasseltii*, but material since collected on Mt. Omei, Szechwan Province, and described in 1945 by C. C. Liu as *Vibrissaphora boringii*, genus and species new, convinces me that my determination is erroneous; *Megophrys hasseltii* probably does not occur in China.

Recently Dr. Liu brought 3 topotypical paratypes of his new frog to the Chicago Natural History Museum and we have carefully compared these with my Fukien series. This comparison leaves no doubt in our minds that *V. boringii* and the Ch'ungan Hsien *"hasseltii"* are closely related forms of the genus *Vibrissaphora*. The many points of similarity are: 1. A row of lightly pigmented tubercles extends along the margin of the upper jaw. (The adult male of *V. boringii* develops a conspicuous, black, conical spine on each of these labial tubercles.) 2. The jaws are weak, the mouth large, and the tongue exceptionally wide. This weakness of the jaws is apparently due to the slenderness of the supporting bony structures. 3. There is a small, elongate gland in the groin and an oval one in the axilla. Both are unpigmented and therefore conspicuous. 4. The back is covered with a conspicuous network of granular ridges. The many longitudinal glandular ridges of the upper surfaces of the limbs are more or less connected to suggest a network like that of the back. The skin of the belly is set with a profusion of minute, unpigmented glands. 5. The arms are long and slender, the legs short and weak. Dr. Liu saw the Szechwan frogs walking about in a spider-like manner, a habit no doubt correlated with the slenderness of the limbs. 6. The spaces between the subarticular tubercles of hands and feet are filled by subdigital ridges and tubercles similar in general appearance to the subarticular tubercles. 7. The hands and feet are alike in certain other respects: thickness and degree of webbing, presence of digital fringes, bluntness of digital tips, and marked development of palmar and inner metatarsal tubercles. The subpalmar and subsolar structures are no doubt also correlated with the walking habit.

The following differences, taken together with the fact of geographical remoteness, convince us that two forms are involved: 1. The back of the Fukien frog is of a reddish hue, whereas that of *boringii* is bluish-brown. The dark bars that cross the limbs are more conspicuous in the new form as are also the smaller and more regular dark spots of the back. 2. Although the Fukien specimens are too young for accurate comparison, the tubercles of the upper jaw seem to differ in relative size, those near the angles of the jaws being noticeably larger than the others; the tubercles of the Szechwan frogs are more uniform in size. 3. In *V. boringii* the subdigital ridges predominate over the tubercles in the interspaces of the subarticular tubercles of hands and feet, whereas in the Fukien frogs the subdigital tubercles are more strongly in evidence.

Probably additional characters will be found when older specimens from Fukien and tadpoles from Szechwan become available.

Vibrissaphora ***liui,*** sp. nov.

TYPE.—No. 24427 Chicago Natural History Museum, a recently metamorphosed individual from the region of San Chiang, Ch'ungan Hsien, Fukien Province, China. Collected by Clifford H. Pope in 1926. The description is based on the formalin-preserved condition.

RANGE.—Known only from the type locality.

DESCRIPTION OF TYPE.—The head is broader than long, the snout broad, rounded, and depressed, the mouth wide. The nostril is about as far from the tip of the snout as from the anterior border of the eye; the distance between

the nostrils is slightly less than that between the eyes. The canthus rostralis is sharp and conspicuous, the loreal region concave.

The long, slender arm measures 25 mm. to tip of longest finger, and the lower arm is much longer than the upper. The third finger is much the longest, the others about the same length (the fourth may be a trifle shorter than the other two). The finger tips are unpigmented, rounded, blunt, and scarcely expanded. The spaces between the distinct subarticular tubercles are filled with tubercles and ridges, the former predominating. The palmar tubercles are well developed, the inner one the larger. The fingers have low lateral fringes evident only on close inspection. (Similar fringes are barely discernible in *boringii*.)

The legs are weak and short, the tibio-tarsal articulation barely reaching the angle of the jaw. The heels do not touch when the flexed legs are placed at right angles to the axis of the body. The subdigital ridges and tubercles of the toes are like those of the fingers but the lateral fringes are much more noticeable than in *boringii*. The toes are about one-quarter webbed with a thick webbing. The inner metatarsal tubercle is well developed, the outer lacking.

The back is covered with a fine but conspicuous network of granular ridges. The many longitudinal glandular ridges of the upper surfaces of the limbs are more or less connected to suggest a network like that of the back. A narrow, glandular fold extends straight backward from the eye to a point above the concealed tympanum, where it bends downward toward the shoulder. There is an oval gland in the axilla and an elongate one in the groin; both are conspicuous because of a lack of pigment, and the latter is set obliquely as in *boringii*.

The ground color of the upper surfaces is reddish brown. Numerous small, dark spots are irregularly distributed over the back, and several conspicuous, dark bars cross the dorsal surface of each limb. The somewhat lighter ground color of the belly is interrupted by a great number of small, low, unpigmented warts. There is a dark area behind the nostril and at the anterior and posterior corners of the eye.

Length from snout to vent 41 mm. The last remnants of the tail disappeared shortly before the type was preserved. Traces of the tail are barely evident in a paratype (CNHM No. 24425) that is only 3 mm. shorter than the type.

Description of Tadpole.—The width of the body is about two-thirds its length. The tail is approximately twice as long as the body, three or a little more than three times as long as deep. The nostril is surrounded by a papillate ridge and is as far from the eye as from the tip of the snout. The distance between the nostrils is equal to or slightly less than that between the eyes, which are lateral and slightly nearer to the spiraculum than to the tip of the snout. The vent is dextral, and situated just above the lower border of the subcaudal crest. The tail is pointed, its crests high.

The teeth of the upper lip are in six rows, all but the outer row, which is very short, interrupted; those of the lower lip are in five rows with all rows but the outer interrupted. All the teeth are set on prominent, fleshy ridges. The row of papillae that borders the lips is narrowly interrupted in

the middle of the upper lip. A few extra papillae are present in the corners of the mouth.

The body and tail are dark reddish brown, the crests translucent with small, dark spots. At the dorsal junction of tail and body there is a dark-bordered, light, V-shaped mark that greatly facilitates field recognition but is not conspicuous in preserved material. The living larvae of *Rana spinosa* and *V. liui,* although strikingly alike in size, form, and color, cannot be confused because the former lacks this characteristic.

A mature paratypical tadpole of average size has leg buds 12, body 30, and tail 63 mm. long; the biggest tadpole of the large series has legs 26, body 36, and tail 72 mm. in length.

This tadpole and its mouth parts were illustrated by me in 1931.

PARATYPES.—All known material of this species was collected by me at the type locality and listed in 1931 as 20 metamorphosing and very immature individuals (AMNH No. 30682) and 4 lots of tadpoles (AMNH Nos. 29018, 29020, 30681, and 32947). Six of the series of 20 are now CNHM Nos. 24422-27, and 2 of the series of tadpoles have also been transferred: No. 29018 as 24420 and 32947 as 24421.

REMARKS.—In Ch'ungan Hsien the tadpoles frequented the deeper pools of both large and small mountain-forest streams. They seemed to be confined to these deeper pools even though younger individuals could be found as well nearer the current in small, shallow pools. These tadpoles are unusually sluggish and therefore easily taken. The whereabouts of the adults remains a mystery; all the young frogs secured transformed in confinement. My Chinese helpers, with whom I collected intensively in Ch'ungan Hsien for months, maintained that this species breeds only in late autumn when adults may be traced by their loud croaks to deep recesses under boulders lying along the forest streams.

Vibrissaphora boringii is only one of the many remarkable amphibians found in western China by Dr. C. C. Liu so I take great pleasure in naming my new form after this indefatigable explorer and zoölogist. Discovery of this and several other new pelobatid species, in itself a major achievement, is only a small part of Dr. Liu's accomplishment.

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CHICAGO NATURAL HISTORY MUSEUM, CHICAGO 5, ILLINOIS.

Studies on the Growth of Tagged Toads (*Bufo terrestris americanus* Holbrook)

By Edward C. Raney and Ernest A. Lachner

STUDIES on the migrations, growth, homing, and other phases of the life histories of the toads and frogs of the Ithaca, New York, region were begun in 1940. The early report of Wright (1914) furnishes a background for our investigations, in which we have attempted to obtain more detailed information by observations of marked individuals throughout the warmer months and from year to year. Some recoveries were made and additional specimens were marked in 1941 and 1942. The tagging was resumed in 1946, but, although several toads marked sometime between 1940 and 1942 were observed by others, none were captured and measured by us.

The toads, all *Bufo terrestris americanus* Holbrook, the only *Bufo* found in the Ithaca area, were marked by the use of metal tags locked securely around the lower jaw. This method was successfully used by the senior author (1940) for marking frogs. In 1940 and 1941 only a medium sized tag of satisfactory thickness was available but in 1942 a smaller one, called a fingerling tag,[1] was used. It is a much better size for toads and smaller frogs. The toads often pulled at the tags when first inserted but after a few days they appeared to ignore them. Most toads carried the tag in the mouth along side or under the tongue. The growth and behavior of some individuals, especially those marked with the larger tags, are probably affected.

Some error is involved in making measurements on living toads. In our practice they are first placed in a sitting position and then pushed downward so that the back is straight and parallel to the steel rule upon which they rest. The length is then taken from the tip of the snout to the posteriormost point between the hind legs. This method was always used in our studies and the same individual made all measurements. In order to check the degree of accuracy of measurement a test was run on 10 tagged toads in which each was taken at random and was measured ten times. The length of small males was repeatedly measured to within ± 1 mm. The larger turgid females and biggest males could not be remeasured with as great accuracy and varied ± 2 mm. In a recaptured individual this error in measurement may be such as to completely annul the growth increment. However, in dealing with large numbers this error probably tends to average out.

Nightly trips beginning just before dusk were made to the ponds at the Cornell Experimental Fish Hatchery after the ice went out in late March, 1940. After a rather cold spring the first *Bufo*, a male, was heard and captured on April 29. Breeding of toads occurred during the next two-week period with only short interruptions when the early evening air temperature dropped below 50° to 55° F. Most matings were accomplished at night and only a few males remained in the water during the day. However, at times when the temperature was high, large numbers continued breeding activities throughout the night and the next day. We attempted to capture and tag

1 Style No. 1005, size 1, and applicator are available from the National Band and Tag Company, Newport, Kentucky.

all toads in the area and believe we obtained a very high percentage of the breeding population. The following data on sex ratios are based only on the new toads marked on a given date and not on the total number of tagged males and females present: May 1, 73 to 7 (males to females); May 2, 169 to 8; May 3, 1 to 0; May 7, 81 to 1; May 8, 13 to 1; May 10, 4 to 1; May 13, 81 to 6; May 14, 20 to 8; and May 15, 5 to 1; total 451 males and 33 females. The length frequencies of these toads as well as those tagged in other years are given in Table I. The following year, 1941, was rather

TABLE I

LENGTH FREQUENCIES OF *Bufo terrestris americanus* TAGGED FROM 1940–46 ON THE CORNELL CAMPUS, ITHACA, NEW YORK

Locality	Year Tagged	Sex	Length in mm. 55	60	65	70	75	80	85	90	95	100	105	110	115	Total
Experimental	1940	♂	2	5	49	158	130	69	31	5	1	1	...	...	...	451
		♀	...	...	...	...	...	1	9	5	8	8	1	1	..	33
Fish Hatchery	1941	♂	1	...	2	11	47	63	29	7	1	...	...	...	...	161
		♀	...	...	...	...	...	2	11	15	12	14	8	1	1	64
Ponds	1942	♂	...	...	5	15	25	28	9	1	...	...	...	...	...	83
		♀	...	...	...	...	...	...	3	4	4	1	...	...	...	12
	1946	♂	...	1	12	26	18	16	14	3	1	...	...	...	...	91
		♀	...	...	...	...	1	1	13	19	7	10	5	...	...	56
	Total	♂	3	6	68	210	220	176	83	16	3	1	...	...	...	786
		♀	...	...	...	...	1	4	36	43	31	33	14	2	1	165
Rifle Range	1941	♂	...	...	3	13	17	14	16	4	...	...	...	...	...	67
		♀	...	...	...	...	...	...	...	1	1	4	...	1	...	7
on Fall Creek	1942	♂	...	...	1	9	26	22	17	4	...	...	...	...	...	79
		♀	...	...	...	...	...	...	...	2	2	6	...	...	...	10
	Total	♂	...	...	4	22	43	36	33	8	...	...	...	...	...	146
		♀	...	...	...	...	...	...	...	3	3	10	...	1	...	17
	Grand Total	♂	3	6	72	232	263	212	116	24	3	1	...	...	...	979
		♀	...	...	...	...	1	4	36	46	34	43	14	3	1	193

poor for observation, with relatively few warm nights. However, 88 (19.5 per cent) males and 2 (6.1 per cent) females were recaptured and additional ones were tagged at the Fish Hatchery and at the Cornell Rifle Range on Fall Creek where the toads used a small backwater above a dam as a spawning site. Relatively little time was given to toad hunting in the spring of 1942 but 18 males and 1 female were retaken at the Fish Hatchery and 18 males and 3 females recaptured at the Rifle Range. Out of a grand total of 679 males and 104 females tagged in 1940 and 1941, 124 (18.3 per cent) males and 6 (5.8 per cent) females were recaptured in 1941 and 1942. The annual growth increments of these toads are summarized in Tables II to IV.

Considerable variation in annual increment at any given size is demonstrated. The average increment was 3.0 mm., which indicates a rather slow rate of growth after reaching maturity. Small males grew more. The lowest quarter (range in length from 63 to 72 mm.) gained 4.8 mm. The second quarter (range 73 to 76 mm.) gained 4.0 mm., while the third quarter (range 77 to 81 mm.) gained 2.9 mm. The highest quarter (range 82-94 mm.) had a mean gain of but 0.1 mm. Only 8 out of 124 males gained as much as 10 to 15 mm. each in one year. Twenty-five (20.2 per cent) of the total either showed no increment or some decrease. The correlation between

TABLE II

DIAGRAM SHOWING LENGTH AND ANNUAL GROWTH INCREMENT OF 124 TAGGED MALE *Bufo terrestris americanus* MARKED IN 1940 AND 1941 AND RECOVERED IN 1941 AND 1942 AT THE CORNELL EXPERIMENTAL FISH HATCHERY AND RIFLE RANGE ON FALL CREEK, ITHACA, NEW YORK

Number	1	3	2	3	5	9	9	6	8	12	4	9	7	3	5	9	6	6	3	5	3	1	3	1	1	124
Mean annual increment in mm.	6	9.3	9	9	5.4	6.3	5.4	4.5	4.4	3.7	3.2	2.2	3.7	3.0	4.0	2.4	3.7	−1.5	−.3	0	−1	0	−.7	−4	−3	3.0
Annual growth increment in mm. 15	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1
14	..	..	..	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1
13	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1
12	..	1	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	2
11	..	..	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1
10	..	..	..	..	..	2	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	2
9	..	1	2	..	..	3	1	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	8
8	..	..	..	..	..	..	1	1	..	2	..	..	1	..	1	..	..	..	..	..	..	..	..	..	..	6
7	..	1	..	..	1	..	..	..	..	1	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	4
6	1	..	..	..	1	..	1	..	2	1	..	..	1	..	..	1	..	..	..	..	..	..	..	..	..	8
5	..	..	..	..	..	1	1	..	1	1	1	..	..	1	1	1	3	..	..	..	..	..	..	..	..	11
4	..	..	..	..	..	..	1	..	2	1	1	3	..	..	2	2	2	..	1	1	..	..	..	..	..	16
3	..	..	..	..	..	..	1	..	1	1	..	1	1	1	..	..	..	..	..	..	1	..	..	..	..	7
2	..	..	..	1	1	2	1	2	..	..	2	3	1	..	..	2	..	1	..	..	..	..	..	..	..	16
1	..	..	..	..	..	1	1	1	..	4	..	..	1	1	..	1	..	1	..	1	..	..	1	..	..	13
0	..	..	..	..	..	..	..	1	..	..	..	1	..	..	..	1	..	..	..	1	1	1	1	..	..	7
−1	..	..	..	..	..	..	..	..	..	1	..	1	1	..	1	..	1	..	..	..	..	..	..	..	..	5
−2	..	..	..	..	1	..	..	..	1	..	..	..	..	..	..	1	..	2	1	1	..	..	..	..	..	7
−3	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	1	1	..	..	1	..	1	5
−4	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	..	..	..	..	..	1	..	2
−5	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	..	..	..	..	1
	63	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	94	No.
	Length in mm. when first tagged																									

length and annual growth increment, which may be observed in Table II, is statistically significant.

The measured loss in length of certain specimens, mostly the larger ones, may be only apparent rather than real and due to unavoidable error in measuring living toads. Another possible explanation assumes an actual loss of length due to a possible harmful effect of the tag, which may have interfered with normal feeding in some. Or it may be that the longest and oldest toads actually shrink in length. Most credence is given to the first explanation.

Three males tagged in 1940 were retaken both in 1941 and 1942. The results are shown in Table III.

TABLE III

GROWTH INCREMENTS OF MALE *Bufo terrestris americanus* FROM CORNELL EXPERIMENTAL FISH HATCHERY TAGGED IN 1940 AND RECOVERED IN 1941 AND/OR 1942

	Year Tagged	Year Captured	
	1940	1941	1942
Length in mm.	76	78	80
	76	80	79
	73	81	83
	74	..	80

TABLE IV

GROWTH INCREMENTS OF FEMALE *Bufo terrestris americanus* RECAPTURED AT THE CORNELL FISH HATCHERY AND RIFLE RANGE

Year	1940	1941	1942	Gain or Loss
Length in mm.	90	99	...	9
	110	114	...	4
	...	88	88	0
	...	103	103	0
	...	92	90	− 2

Only 6 females were recaptured and these data are given in Table IV.

Hamilton (139: 88) found that young toads in the Ithaca region attained maturity at two years of age. Our results indicate that adults grow slowly and probably reach a point fairly close to their maximum length in three or four more years.

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Notes on Salamanders Collected in Oklahoma [1]

By Harold A. Dundee

THE recent descriptions of new salamanders, *Eurycea tynerensis* Moore and Hughes, *Eurycea griseogaster* Moore and Hughes, and *Typhlotriton nereus* Bishop, prompted the writer to collect and study salamanders in the Ozark uplift in northeastern Oklahoma. The observations presented herein are mainly from northeastern Oklahoma although interesting notes from other regions of the state are included.

Some specimens were placed in the University of Oklahoma Museum of Zoology. Some were presented to Dr. G. A. Moore, and the remainder are in the writer's personal collection.

Ambystoma maculatum (Shaw).—An egg mass collected Feb. 28, 1944, in an overflow pool of a small spring fed stream 2 miles south of Scraper, Cherokee County, was taken to the laboratory where the larvae began emerging on March 10. Unfortunately these larvae failed to survive but others were collected later (Mar. 28, June 11, 16, and 25) in abundance. On June 16 metamorphosing larvae were found and carried to the laboratory where they developed the adult color pattern in sufficient detail by June 27 to confirm their identification as *A. maculatum*. A thorough search for adults and newly metamorphosed individuals in the vicinity of the pool was futile.

Ambystoma texanum (Matthes).—Large numbers of this secretive species were taken from beneath logs in a shallow slough 2 miles south of Norman, Cleveland County. Males taken here as early as December 4, 1942, had greatly enlarged testes which contained active spermatozoa. On February 28, 1942, eggs were collected. At the same time larvae about 8 mm. in length were seen swimming in the slough.

Several specimens from Osage County, 3 miles northwest of Tulsa, represent a new locality record.

Ambystoma trigrinum mavortium Baird.—Neotenic individuals of this species were taken April 24, 1942, and June 9, 1943, in a cattle tank 6 miles east of Norman, Cleveland County. In April terrestrial adults were found in the same pool. Neotenic males taken in April had enlarged testes containing active spermatozoa.

The only previous report of neoteny in *mavortium* is from Estes Park, Colorado (Gadow, 1908). The new Cleveland County record is 500 miles southeast of Estes Park and at a considerably lower elevation (1200 ft m.s.l.). This suggests that neoteny in *mavortium* may be considerably more widespread than previously suspected.

Plethodon cinereus angusticlavius Grobman.—A specimen taken 2 miles south of Scraper, Cherokee County, on April 27, 1945, appears to be the first record from Oklahoma. It was found beneath moist leaves in a narrow stream valley in rugged limestone hills.

Another specimen was collected in Adair County, 5 miles south of Kansas, on March 28, 1944.

1 Contribution from the Department of Zoological Sciences, University of Oklahoma. The writer is indebted to Dr. S. C. Bishop for the identification of the *Eurycea multiplicata*, *Plethodon ouachitae*, and *Typhlotriton*, to Dr. Arnold Grobman for the identification of *Plethodon cinereus angusticlavius*, and to Dr. G. A. Moore for assistance in the preparation of the manuscript.

Plethodon g. glutinosus (Green).—The slimy salamander was frequently encountered around springs and fissures in damp limestone ledges and at cave entrances. The following new locality records are presented: Adair County, 4 miles north of Stilwell, 5 miles south of Kansas; Cherokee County, 2 miles south of Scraper; Delaware County, Dripping Springs.

Plethodon ouachitae Dunn and Heinze.—Grobman (1944: 285) says the species is known from three ranges of the Ouachita Mountains. A specimen collected by William H. Thompson 8 miles east of Broken Bow, McCurtain County, on November 14, 1941, was found under a log in a cypress-pine association on the floodplain of the Mountain Fork River. The habitat previously reported for this species is beneath rocks on hillsides.

Typhlotriton nereus Bishop.—A single specimen found May 7, 1945, in a spring 4 miles south of Locust Grove, Mayes County, extends the range of this animal to the western edge of the Ozark plateau. Many larvae of *Typhlotriton spelaeus* were found in the same spring.

Eurycea griseogaster Moore and Hughes.—Previously known only from the type locality, this salamander was collected in abundance in several small temporary tributaries of the Illinois River south of Flint, Oklahoma. These tributaries lie in a region of limestone hills which support a growth of pine, oak, and maple trees. The stream beds, unlike others of the region, are composed of flat beds of limestone and sandstone. Two specimens found amid the moss growing in a spring 2 miles south of Scraper, Cherokee County, on April 27, 1945, represent an exceptional habitat.

Most of the animals were found under rocks, logs, and clumps of moss near and at the edges of the streams. This is in contrast with the statement of Moore and Hughes (1941: 140) that the habitat is under stones in still or running water. They were found in large numbers on February 6, 1944, February 15, 23, and 28, 1945, and April 27, 1945. Attempts to locate them at later dates were unsuccessful.

The coloration of the series varies somewhat from that of specimens from the type locality. The melanophores on the ventrum are not nearly so numerous and the undersurface of the tail is bright yellow. Moore, who has seen my specimens, suggests that this may be a seasonal variation, since his collections were made on March 29 or later. However, the specimens taken on April 27 also had the bright yellow subcaudal surface and relatively few melanophores. Further study appears to be needed to determine if pigmentation changes occur, or if there is possible intergradation with *Eurycea multiplicata*, a closely related species.

New localities are as follows: Delaware County, 2 miles south of Flint; Adair County, 4 miles south of Flint; Cherokee County, 5 miles south of Kansas.

Eurycea longicauda melanopleura (Cope).—Common in the vicinity of caves and springs. Larvae were found transforming on June 4, 1944.

Specimens collected near Locust Grove, Mayes County, on May 7 and June 18, 1944, respectively, and one taken 1 mile southwest of Flint, Delaware County, on August 13, 1944, constitute new locality records.

Eurycea lucifuga Rafinesque.—Common in the vicinity of cave entrances

and springs. This species was readily secured at night when it was found climbing over limestone ledges in the vicinity of springs.

Previously unreported localities are: Mayes County, 4 miles south of Locust Grove, April 13, 1941; Adair County, 5 miles south of Kansas, May 13, 1944.

Eurycea multiplicata (Cope).—Neotenic salamanders collected in a small stream 6 miles northeast of Tahlequah, Cherokee County, on June 4, 1944, have been identified as this species. The entire *multiplicata* population of the stream is supposedly neotenic, no normal larval forms having been identified. Normal larvae were collected in Flower Creek, 4 miles north of Fort Gibson, Cherokee County, on February 8, 1945.

Eurycea tynerensis Moore and Hughes.—A single specimen collected January 25, 1945, in Salina Creek, 3 miles south of Salina, Mayes County, extends the range of this species nearly 35 miles northwest of any previously reported station. It was found in a clump of water cress growing in the gravelly bed of the stream. At the place of collection the stream emerges from the uplands onto the flood plain of the Grand River.

A large number of specimens of this species have been taken in a small tributary of the Illinois River, 2 miles south of Scraper, Cherokee County. This locality was listed as the source of *Eurycea tynerensis* from which two new parasites were described by Hughes and Moore (1943a, 1943b). No description is given of the stream other than to say it is called Peavine Creek and is a tributary of the Illinois River.

Peavine Creek, unlike Tyner Creek (the type locality) and Salina Creek, is an intermittent stream. It is situated between high limestone hills and receives its water from springs. During the summer it becomes discontinuous, running a brief distance then disappearing into the ground only to reappear farther downstream. The largest numbers of animals are found in the flat, gravelly stretches of the stream. Here they hide in the spaces between the stones or are seen swimming around. Whether the animals seek refuge in the flowing portions of the stream or enter subterranean passages during the summer has not been determined.

In view of the fact that Bishop (1944) recognized neoteny in *Eurycea multiplicata*, which is remarkably similar to *Eurycea tynerensis* except in size, the identity of the above mentioned Peavine Creek salamanders is placed in some doubt. It should also be pointed out that Bishop does not indicate whether or not a whole population of *E. multiplicata* may be neotenic, stating merely that "*Eurycea multiplicata* also enters caves, apparently as a larva, and *may* [my italics] continue as a neotenic individual becoming very pale and resembling *Typhlotriton*."

Mr. James Kezer of Cornell University (personal communication) has forced metamorphosis of *E. tynerensis* with thyroxin. By applying these methods to the Peavine Creek salamanders and comparing them structurally with *multiplicata* a clear cut determination may be established.

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The "New Guinea" Snapping Turtle (*Chelydra serpentina*)

By ARTHUR LOVERIDGE and BENJAMIN SHREVE

MORE than forty years have elapsed since Douglas Ogilby (1905: 11), when listing the turtles in the Queensland Museum, recorded a snapping turtle as coming from the Fly River, New Guinea. No collector was mentioned. Though many collectors have visited New Guinea since 1905, no second specimen has been taken.

Recently our colleague, Dr. Philip J. Darlington, Jr., in the course of his zoogeographical studies, questioned the accuracy of Ogilby's data. Darlington remarked that he had seen in several Australian Museums a scattering of the more striking elements of the North American herpetofauna, and suggested a transposition of labels might have taken place. In other words that the type of *Devisia mythodes*, as Ogilby called it, might be a common snapper (*Chelydra serpentina*). In the hope of being able to settle the point, Darlington wrote to Mr. George Mack, Director of the Queensland Museum, who very kindly supplied him with two excellent photographs of the type viewed from above and below. There is nothing in these photographs to suggest that *D. mythodes* is anything but a synonym of *C. serpentina*, probably of the typical form.

Ogilby's brief description of the genus *Devisia* reads: "Orbit lateral. No supramarginal shields. Tail with irregular shields of variable size inferiorly." A footnote adds that it is difficult to observe the precise arrangement owing to the median ventral surface of the tail having been split by the skinner. Apparently Ogilby lacked comparative material of *Chelydra* and relied on Boulenger (1889: 20), whose definition of the genus (transposed) reads: "Orbit directed outwards and upwards. No supramarginal shields. Tail with large shields inferiorly."

We suggest that there is no real difference in the position of the orbits. The subcaudal shields, characterized as large by Boulenger, might well be considered small by another worker, while the irregularity stressed by Ogilby

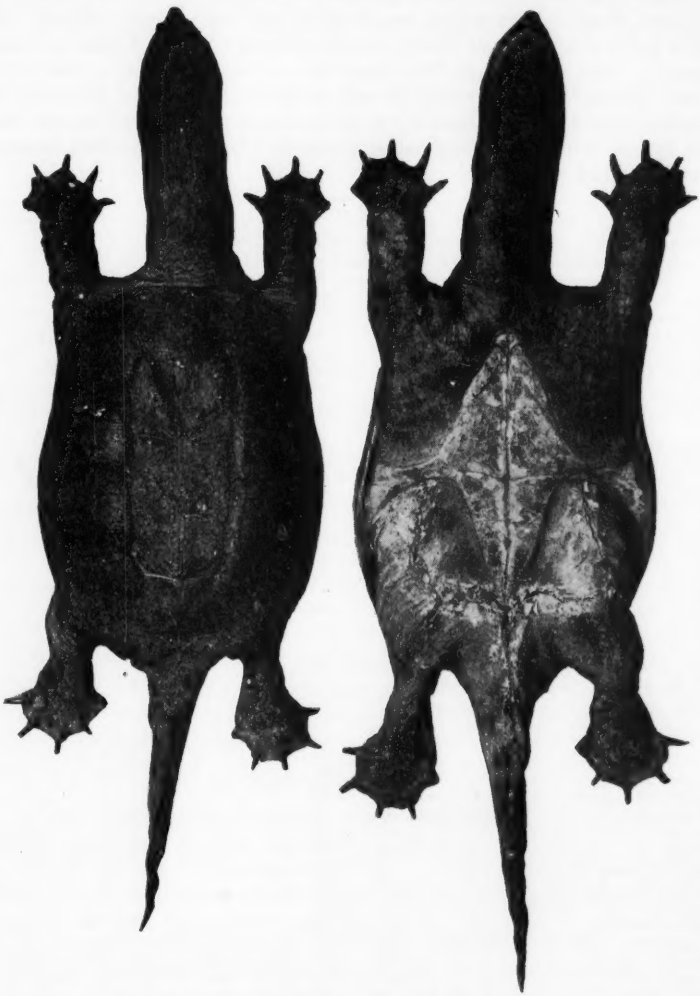

Fig. 1. Type of *Devisia mythodes* Ogilby = *Chelydra serpentina* Linnaeus.

may, in part, be due to drying out. Nothing is said as to the sex of Ogilby's holotype, but if the plastron is as flat as appears from the photograph it may be a female. We have read over the four pages occupied by Ogilby's meticulous description and, after making due allowance for minor variations

and interpretation, find it in substantial agreement with a snapper of comparable size.

As the holotype of *mythodes* is crudely stuffed, with neck abnormally elongated, it serves no useful purpose to compare its "total length" or "length of neck" with that of our alcoholic male from Pungo, Virginia. We give below a selection of Ogilby's measurements with our figures for comparison, though we attach little importance to measurements of individual turtle shields, which are known to vary widely from individual to individual. Ogilby measured every shield of the carapace and plastron, and we find that his figures correspond throughout with ours for *Chelydra serpentina*, allowing for individual variation.

Measurements in Millimeters (Ogilby's terminology retained)	*Devisia mythodes*	*Chelydra serpentina* (M.C.Z. 43400) Male	
Length of carapace	330	340	
Width of carapace	260	279	
Height of body	133	130	Measured between two blocks
Length of plastron	250	246	
Width of plastron	257	250	
Length of nuchal shield	40	42	Normally one would be inclined to reverse these, calling them breadth and length respectively.
Width of nuchal shield	11	11	
Length of supracaudal shield	43	46	
Width of supracaudal shield	32	37	
Length of first vertebral shield	62	66	
Width of first vertebral shield	89	102	
Length of second vertebral shield	70	73	
Width of second vertebral shield	100	103	
Length of third vertebral shield	67	65	
Width of third vertebral shield	100	102	
Length of fourth vertebral shield	57	60	
Width of fourth vertebral shield	92	99	
Length of fifth vertebral shield	74	77	
Width of fifth vertebral shield	102	117	
Length of gular shield	20	30	
Width of gular shield (along outer border)	20	27	
Length of humeral shield	55	55	
Width of humeral shield	44	40	
Length of pectoral shield	62	55	
Width of pectoral shield	63	63	
Length of displaced abdominal shield	25	29	
Width of displaced abdominal shield	73	69	
Length of femoral shield	43	54	
Width of femoral shield	49	49	
Length of anal shield	81	72	
Width of anal shield	31	29	
Length of head mesially	90	106	
Length of snout	17	18	
Length of mandibular symphysis	22	17	Somewhat difficult to accertain.
Diameter of eye	15	17	Orbital opening; shrunk in *mythodes*?
Length of tail	300	300	From end of plastron! Only 180 from anus!

In conclusion we should like to thank Dr. Darlington for the steps he took that have led to the rectification of the allegedly curious distribution of Chelydridae, a family now confined to the New World.

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MUSEUM OF COMPARATIVE ZOOLOGY, CAMBRIDGE, MASSACHUSETTS.

Two New Frogs of the Genus *Scutiger* from West China

By CH'ENG-CHAO LIU

AMONG my collections of amphibians made in West China during the period from 1938 to 1946, I find a very distinct new species of pelobatid frog of the genus *Scutiger,* in addition to the recently described *Scutiger pingii* and *rugosa;* and further consideration of the original description of *Scutiger sikkimensis* indicates that the specimens referred to this species by me in 1940 and 1943 and by Pope and Boring in 1940, clearly represent still another undescribed form. The four species of this genus in my own collections appear to be well defined forms. *Scutiger alticola,* from western Tibet, is not known to me from specimens, but is also distinct, its toes being fully webbed. *Scutiger sikkimensis,* the type species (as redescribed by Miss Procter in 1922), has remarkably small choanae, and has the tongue scarcely notched as compared with the Chinese species.

Scutiger ***schmidti,*** sp. nov.

TYPE.—No. 156, Liu Collection; adult male, Mt. Omei, Szechwan; 7800 feet altitude; July 6, 1945; collected by C. C. Liu.

DIAGNOSIS.—A distinct species of *Scutiger* with relatively large choanae; with many small warts provided with black spines on the back; with indistinct bars on the legs; webs slightly indicated; belly not marbled; a pair of obliquely elongated chest glands in the male, crowded with fine black spines; a triangular dark brown mark between the eyes, extending posteriorly to join the same colored mark on the back. The hind leg is short, as in *pingii,* but *pingii* has the digits distinctly webbed.

DESCRIPTION OF THE TYPE.—Tongue elliptical, free behind and distinctly notched; head moderately large, longer than broad; snout rounded and slightly projected beyond the mouth; canthus rostralis feebly indicated; loreal region oblique and flat; nostril about mid-way between the tip of the

snout and the anterior border of the eye; internasal space about equal to the interorbital space, which is broader than the upper eyelid; length of the eye greater than the orbital space; tympanum hidden; spines on the margins of the upper and lower jaws and a more or less circular spiny area on the median ventral side of the lower jaw; black spines strongly developed on the tympanic region.

Arm rather long; fingers slender and long, first finger equal in length to the second, both shorter than the fourth finger and the third finger about twice as long as the first two; nuptial spines developed on the inner dorsal sides of the first and the second fingers; subarticular tubercles not evident, two large prominent palmar tubercles, the outer one smaller than the inner; warts with spines on the outer side of the arm and smooth warts on the inner side; in front of the base of the arm, pre-humeral warty area.

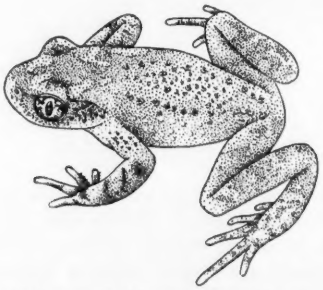

Fig. 1. *Scutiger schmidti,* adult ♂, from Mt. Omei, Szechwan; natural size.

Hind limb moderately long and relatively weak, tibiotarsal articulation reaching the angle of the mouth; heels just meet when placed at right angles to the body; tibia 43.1 per cent of the body length, webs barely indicated and toes fringed; spines on the outer fringes of the fifth and fourth toes; no subarticular tubercles; inner metatarsal tubercle elongated, rod-like and flat, no outer metatarsal tubercle, many large and small spines scattered on the hind limbs especially on the dorsal side, each femur with a light-colored flattened gland on its posterio-middle region.

Skin very rough with many small warts on the back of the body and sides of head and body and all over the limbs; warts provided with many small spines especially on the back of the body, very much like those of *Bufo bufo gargarizans;* larger spines along the margin of the jaws, tympanic region and the posterior ventral aspect of the thigh; some fine and a few large spines on the belly.

The dorsum is grayish brown in ground color, with dark brown or nearly black marks on the jaws and the anterio-dorsal side of the snout; a similarly colored mark starting from the anterior region of the interorbital space, including the eyelids and extending posteriorly, covering the whole back to the vent; the posterior part of the back nearly black, from the presence of many small and a few large black spines; the exposed parts of the limbs also grayish brown, with irregular dark brown bars; sides of the body lighter and with

scattered still lighter colored warts; throat, belly and the ventral sides of the limbs purplish flesh in color and semitransparent, as in *Kaloula;* digital tips very light in color; pupil black, vertically oval, sometimes even squarish, with black connections dorsally and ventrally; iris golden, stippled with black, the ventral part slightly darker than the dorsal portion.

Scutiger ***popei,*** sp. nov.

TYPE.—No. 227, Liu Collection; adult male, Lungtung, Pao-hsing (Mupin), Sikang; altitude 3400 feet; August 19, 1939; collected by H. W. Chang.

DIAGNOSIS.—A distinct *Scutiger* apparently related to *S. sikkimensis,* but with the choanae very large; tongue large and deeply nicked behind; tibio-tarsal articulation reaching beyond the eye; toes with rudimentary webs; round black warts more or less regularly scattered on the back, with brown lines radiating out from each wart and forming a net-work on the back; very well developed black bars on the limbs, on the two outer fingers and three toes; black spines on the first and second fingers; chest glands elongated, widely separated from each other and strongly divergent posteriorly.

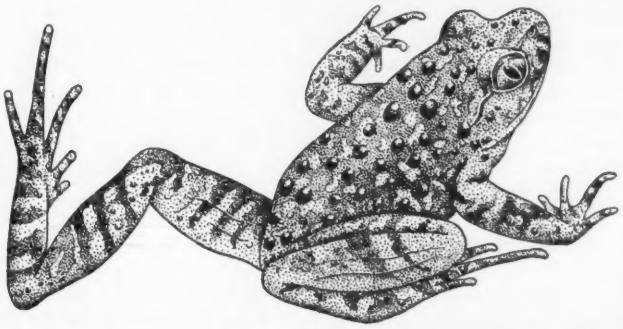

Fig. 2. *Scutiger popei,* adult ♂, from Lungtung, Pao-hsing (Mupin), Sikang; natural size.

DESCRIPTION OF TYPE.—Body moderately slender; head somewhat depressed; as long as broad; tongue broad, free behind and deeply nicked; no vomerine teeth; choanae very large; snout rounded, slightly projecting beyond the mouth, and much longer than the length of the eye; canthus rostralis obtuse; loreal region very oblique, concave; nostrils nearer to the tip of the snout than to the anterior corner of the eye; interorbital space greater than internasal, and broader than the upper eyelid; tympanum hidden.

Arm strong, fingers slender and long, first and second about equal in length, but shorter and thicker than the third and fourth, the third finger the longest; nuptial spines number 11 on first and 8 on the second finger of the left hand, and respectively 10 to 5 on the right hand; tips of fingers rounded and lighter in color, subarticular tubercles present; thickened skin between the subarticular tubercles, especially the two outer fingers; palmer tubercles

large and prominent, a large inner one at the base of the first finger and a much smaller one opposite the base of the third.

Hind limb slender and long, the tibio-tarsal articulation reaching beyond the eye; length of tibia 48.8 per cent of the body length; foot 49.2 per cent of the body length; toe slightly fringed with rudimentary webs, subarticular tubercles better developed than on the fingers, thickened ridges found between the subarticular tubercles; inner metatarsal tubercle oval, with a free edge; no outer metatarsal tubercle.

Skin rough; small warts on the top and sides of the head, especially posterior to the angle of the mouth, and on the dorsal sides of the limbs; larger round warts more or less regularly scattered on the back and the sides of the body; fine warts on inner anterior side of the arm, with a definite warty area on antero-ventral region at the base of the arm; two well developed chest glands, covered with fine spines, located on the thorax; the length of this gland is about 8 mm. and the breadth 4 mm.; rounded axillary glands make contact with the posterio-lateral corners of the chest glands at the arm pit on each side; a large flattened gland, light at center and dark colored at periphery, on the mid-posterior aspect of each thigh; skin smooth on throat, belly and ventral sides of the legs.

Coloration in Life.—Ground color of the top and sides of head, the back and sides of the body and dorsal sides of the limbs brownish yellow; rounded black or dark brown spots with light centers and brown processes radiating out from each spot are correlated with the dorsal warts. The markings extend from spot to spot and form a network on the body; smaller black spots on the top of the head; black bars on the jaw, dorsal sides of the limbs, the two outer fingers, and the three outer toes; throat, belly, and ventral sides of limbs flesh-purple in color; throat, sides of belly and ventral sides of limbs strongly marbled with brownish gray. The eye is very large and has a vertical pupil which can be changed from oval to slit-like form as in the cat, the size of which is regulated by the intensity of the light. The color and the shade of the iris is striking; the upper half is stippled with gold and black, but the gold is dominant; the lower half of the iris more vertically stippled black than gold. Therefore the upper half of the eye-ball is bright and the lower half is dark. After preservation the ground color of the back is light cinnamon drab, the black spots cover the warts, and the light brown network disappears.

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The Home Ranges and Wanderings of Snakes

By William H. Stickel and James B. Cope

ONE of the basic instincts of animals is to establish home areas within which the individuals are familiar with their surroundings. As more groups are studied more examples of such relationships appear. Some type of territorial behavior has been found in each major class of vertebrates and in certain invertebrates (Pearse, 1926: 92–93; Heape, 1931: 322–323). The details vary widely with the nature of the animal and its environment, as may be seen from the numerous examples cited by Heape, but the general principle is now so well established that it would be surprising to find unquestionable proof that adult members of any species of terrestrial vertebrate habitually moved about at random.

An important distinction is made between the home range and the territory (Burt, 1943). The home range is the area within which the individual ordinarily moves about in the course of its day to day activities. Journeys away from the home range may be made for varying periods of time, or the home range may be shifted, without violation of this concept. The territory is the part of the home range that is defended. It usually includes nesting or food storing sites. The territory is exclusive to an individual or a family of a given species, but much of the home range may be neutral country. Species may have home ranges but no territories.

Summaries and references on this subject are given for fishes by Breder (1936), Noble (1938), Noble and Curtis (1939), and Rodeheffer (1941); for birds by Nice (1941), and for mammals by Burt (1943).

Frogs and toads of many kinds have resting sites and calling stations to which they habitually return (Noble, 1931: 403–407). Field studies have demonstrated the presence of homing ability in the Salientia, and have shown that while some individuals travel thousands of feet many others remain within a few hundred feet or less of the point of first collection (McAtee, 1921; Breder, Breder and Redmond, 1927; Raney, 1940; Ingram and Raney, 1943). Apparently neither home ranges nor homing have been observed for salamanders, but this may be due to the lack of any satisfactory method of marking these animals for long term studies.

Territoriality in lizards is well known (for discussion and references see Evans, 1938; Fitch, 1940; Stebbins, 1944 and 1946; Woodbury and Woodbury, 1945). Various authors have concluded that both aquatic and terrestrial turtles have home ranges to which they will usually attempt to return if displaced. Knowledge of the ranges and travels of turtles has recently been summarized and extended by Cagle (1944). He found no evidence of defensive territorialism. McIlhenny (1935: 26, 87, 88) states that the alligator usually returns to the same wintering den each year throughout life, and that females frequently use the same nesting site year after year. Territoriality evidently occurs in the alligator, for McIlhenny remarks that:

> Large male alligators are very intolerant of the near approach to the place in which they live, of other large males, and I think most of the roaring they do is for the purpose of warning away any other who might invade their range. The males fight each other

fiercely and it is not uncommon to find large males with a foot or leg missing, or a considerable section of its tail gone, or severe scars on its body, which could only be made by other alligators. I have often seen them fighting.

In the light of all the evidence for home ranges in the other groups of reptiles, it is surprising to find that the few authors who have mentioned the ranges and wanderings of snakes have concluded that they move about at random, or that they are merely sedentary, moving randomly after leaving any one spot. In the present paper evidence is given that snakes do have home ranges, and explanations are offered for the opposite conclusions of previous authors.

METHODS.—The work was done at the Patuxent Research Refuge of the U. S. Fish and Wildlife Service in Prince Georges County, Maryland. The Refuge lies midway between Washington and Baltimore, along the Patuxent River, on the upper part of the coastal plain. The vegetation is rather well diversified, with extensive deciduous forest on the bottomlands, several cultivated fields, fields in various stages of reforestation and large tracts of pine and oak woodland on the uplands. The Refuge and its vegetation have been described by Hotchkiss (1940).

The snakes were marked by clipping combinations of the subcaudal scales according to the system of Blanchard and Finster (1933).

The localities of collections were recorded in terms of distance and direction from the permanent, numbered, survey markers that are placed at the corners of the 330 foot square plots into which the Refuge is divided. The animals were brought to the laboratory for marking and measuring and later released as near as possible to the point of collection.

The data here reported were gathered in the three and one half years between the beginning of marking in August, 1942, and the close of the 1945 season. In this period 246 snakes of 13 species were marked, of which 23 were recovered at least once. Sixty-two *Elaphe obsoleta* and 38 *Coluber constrictor* were marked, with 16.7 per cent and 13.8 per cent returns. For other species there were only six repeats divided between five species.

DISCUSSION OF RESULTS.—If snakes have no home ranges and wander more or less at random as authors have stated, or if they are merely sedentary, the distance traveled between captures should average greater and greater as the time interval increases. It will be noted (Table I) that the distances traveled do not increase in proportion to the length of time between captures. Instead, the reptiles usually moved no further in a year or two than they did in a few days. Most of them, indeed, were found but a few hundred feet from the place of original collection, and in but one record is travel of more than 1760 feet shown. The snakes may or may not have wandered extensively during the period between collections, but they displayed a strong tendency to remain within, or to return to, a limited region within which they were first found. Several of the specimens were found, after months or years had passed, in the same hedgerow, the same patch of woods, or the margins of the same field in which they were originally caught. In other words, these species apparently do have home ranges and these ranges are of quite finite size.

Although our records are too few and are from too many habitats to reveal the size of the true home ranges, we can derive from the data some idea of the magnitude of the areas traversed by individual *Elaphe* and *Coluber*. The average distance between points of collection for *Elaphe* at large for more than 3 days is 816 feet. The same figure for *Coluber*, all of which were free for 2 years, is 802 feet if the single record of 1.1 miles is omitted. Presumably these figures roughly represent average movements within the home range. The area involved in travels of this extent is greater than might be

TABLE I

DISTANCES BETWEEN POINTS OF CAPTURE OF MARKED SNAKES

Time elapsed	Distance moved	Remarks
Elaphe o. obscleta:		
3 days	330 ft.	Young, 332 mm. In Hq. area. September.
6 wks.	880 ft.	Across a field. June–August.
8 mos.	1760 ft.	From woods to road margin in Hq. area. Sept.–May.
8.5 mos.	1580 ft.	Along road in woods. Sept.–June.
1 yr.	660 ft.	Within Hq. area. June–May.
13 mos.	200 ft.	Along road in woods. May–June.
13 mos.	600 ft.	Woods along brook. August-September.
14 mos.	130 ft.	Within woods margin area. July–September.
14 mos.	1155 ft.	Mixed habitats. May–August.
2 yrs.	380 ft.	In bottomland forest. May–May.
Coluber c. constrictor:		
1 day	300 ft.	Vicinity of animal pens. May.
3 days	340 ft.	In bottomland forest. April.
2 mos.	500 ft.	In bottomland forest. April–June.
2 yrs.	1320 ft.	Margins of same pine field. April–April.
2 yrs.	400 ft.	In same hedgerow. May–April.
2 yrs.	990 ft.	Along lake margin in open field. June–June.
2 yrs.	1.1 mi.	From lakeside field to bottomland forest. June-May. (Error is possible, as the snake was kept in the laboratory 26 days and was released by a second person.)
Heterdon c. contortrix:		
5.5 mos.	100 ft.	Mixed habitats. October-March.
Lampropeltis g. getulus:		
1.8 yrs.	330 ft.	Mixed habitats. July-April.
Lampropeltis calligaster rhombomaculata:		
1 day	0 ft.	Road between old fields. October.
6 wks.	600 ft.	Road between old fields. September-October.
Natrix s. sipedon:		
2 yrs.	380 ft.	Along river. June-May.
Haldea v. valeriae:		
4 days	20 ft.	Window pit to window pit. September.

assumed at first glance. By way of illustration, if the home range is supposed to be circular (which it probably is not) and the average distance between collection sites is used as a radius, the area of the circle would be about 47 acres. Maximal travels across the home range possibly are indicated by the greater distances moved by several specimens: 1760, 1580, 1320 and 1115 feet. However, some of these records may be based upon short journeys beyond the usual range.

It is highly probable that in good hunting country the true home range is much smaller than is suggested by the maximum distances cited. Within

the bottomlands, the most fertile habitat of the Refuge, the recorded travels did not exceed 500 feet. The longest distances were along upland wood margins or around fields. In strip habitats such as wood margins and hedgerows an animal would no doubt find it necessary to travel greater linear distances in order to cover an adequately large area of suitable habitat. Thus the home range might be long and narrow for individuals living primarily in field margins and hedgerows and yet be quite compact for others of the same species living in uniform and productive field or forest habitats.

In view of the motility of the blacksnakes it may seem odd that the home range is as small as the data suggest, for certainly the snakes could quickly traverse much larger areas. Blanchard and Finster (1933) mention a small garter snake that traveled 1800 feet in one hour, while Mosauer (1935) demonstrated that the prowling speeds of *Lichanura, Lampropeltis, Pituophis, Salvadora, Crotalus* and *Masticophis* varied from one tenth to three tenths of a mile per hour. Since the prowling speeds of *Elaphe obsoleta* and *Coluber constrictor* no doubt fall within these limits, the probable width of the home range could be equalled in about one to three hours at ordinary crawling speed. The animal could soon become familiar with the entire area of its range.

Many herpetologists have had the experience of seeing pursued snakes dash without hesitation to a nearby burrow, sometimes even darting past the observer to reach the point of safety. Such happenings not only indicate that the snake is within an area with which it is thoroughly acquainted, but raise the question of whether or not, within the home range, there is a particular "home site" which serves as the center of the individual's activity. It may be that animals are sufficiently familiar with all parts of their range to be seldom at a loss to find a place of refuge when disturbed. Mice, for example, use various burrows scattered over their home ranges, although they have certain ones that they use the most and within which they nest. Many animals will defend this home site and the immediately adjacent region even though territorial behavior is otherwise unknown in the species. It would be interesting to learn whether snakes have such a territory within the home range, and if so, whether they will defend it against others of the same species.[1]

Discussion of the Literature.—References concerning the wanderings or home range behavior of snakes are not numerous, and some of them are so obscurely buried that no mention of the matter appears either in the section headings or summaries of the papers in which they occcur.[2]

Blanchard and Finster concluded that the wanderings of snakes may or may not be extensive and are not predictable. Their views were based upon

1 The possession of any defended territory by snakes is to be questioned, for *Thamnophis*, at least, in view of the enormous local population revealed by Seibert and Hagen.

2 An important paper by Seibert and Hagen has appeared since this article was submitted. These authors recaptured 41 *Thamnophis radix* and 12 *Opheodrys vernalis* in a single season, May 20 to Nov. 4, 1945. The snakes had been released where collected. Distances between points of capture were surprisingly small. Nearly half the snakes moved less than 10 yards; 73 per cent of the *Thamnophis* and 83 per cent of the *Ophcodrys* traveled less than 30 yards. Only one, a *Thamnophis*, traveled as much as 100 yards.

Four snakes were recaptured exactly where released, one of them after six weeks. A *Thamnophis* caught four times, each at a different spot, returned to within 12 yards of its original location.

Possibly longer travels would have appeared in a larger study area. The plot used by Seibert and Hagen was but 3.2 acres and seems to have been somewhat circumscribed ecologically. However, the amazing total of 383 snakes was marked in this plot and no marked snake was found outside the area despite several searches.

the results of releasing at Douglas Lake, Michigan, several hundred snakes which had been collected at various places in northern Michigan. Their work constitutes a valuable experiment on the effect of transplanting animals to a new locality. The imported snakes scattered in all directions, often traveling miles along the lake shore. Three *Thamnophis sirtalis* were recovered at Reeses Bog, which necessitated a trip of about 2 miles over rough, dry upland. No strictly terrestrial snakes were found after the season of release, indicating wide dispersion. On the other hand, of 7 garter snakes released at their points of capture 6 were later found at the same place, while the other was collected 1.5 miles away after 44 days.

Blanchard (1937) released 150 introduced *Storeria occipitomaculata* at the University of Michigan Biological Station at Douglas Lake, Michigan, but had no recoveries in subsequent years. He attributed the lack of returns to the secretiveness, habitat, and wandering propensities of the species. Probably equally important was the inclination of transplanted animals to scatter widely, perhaps seeking their former home ranges or favorable new ones and tending to restore a population pressure normal for the species in the habitat.

Mosauer (1933) studied the diurnal range of *Crotalus cerastes* by following their tracks in the desert sand. He found that the tracks followed a roughly uniform direction, although minor changes in direction were frequent. Mosauer states:

> Apparently the sidewinder does not inhabit a certain permanent refuge, but rambles at night over the desert and settles down for rest at any convenient place, spending each day at a different point, chosen at random. It may be however, that the individual returns during the following night or nights to the point from which it started, thus maintaining a territory covered in several nights, but this does not seem very likely.

The snakes apparently were not marked, so the author could not be sure whether or not he was finding the same individual on different occasions in the same region. Mosauer gives no specific data or examples from which one may judge his conclusion, but it is significant that he was seldom able to follow the trail of a snake for much over 1000 feet before the tracks were lost. In the desert the home range of a snake may need to be considerably more than 1000 feet across. Woodbury and Hardy (1940) state that the desert tortoise, *Gopherus agassizii*, has a home range varying in size from 10 to 40 acres, which is much greater than the range of *Terrapene* in the fertile bottomlands of the Patuxent Refuge. Blair (1943) proved that the home ranges of southwestern rodents were larger than the areas covered by species of similar size in the northeastern United States or in the Sierra Nevada of California. The range of *Microtus* was noted by Blair (1940a) as being greater in dry grassland than in adjacent moist grassland.

Noble and Clausen (1936) studied *Storeria dekayi* on Long Island by marking and releasing. They believed that the snakes wander at random during the summer and early fall and then proceed to a hibernating area. The hibernating den may or may not be the same one used by the snake in other years. Three specimens were found in consecutive years at dens nearly 4000 feet apart. However, the authors' conclusion that wandering is random

is contradicted by their statement that, "The marked snakes usually remained in the region where they were released providing they were originally found there." Thirty-two marked snakes were released at a distance from the collection spot. Thirteen of them, or about 40 per cent, homed to the original site within 70 days. If 13 snakes were found after they returned it is probable that others also homed, for there is no reason to suppose the collectors were 100 per cent efficient. Consequently, it is probable that true homing occurred, rather than that the snakes accidentally reached the original point by random wandering. Since homing is one of the best tests of an animal's adherence to its home-range, the bulk of the evidence presented by Noble and Clausen seems to show that home range behavior is present in *Storeria dekayi*.

Horn and Fitch (1942) marked *Crotalus viridis oreganus* in California grazing country. They give no data or examples, but state that these snakes wander indefinitely with no apparent tendency ever to return to a given spot after leaving it. On the other hand they note that, ". . . on the average the snakes move less than 10 feet a day and many move only a few yards over periods of months." In the absence of specific information in this paper critical judgment is difficult. Possibly the wanderings of juveniles or long trips by a few individuals influenced the authors' conclusion despite the extreme localism prevailing on the average, as indicated in the above quotation.

Imler (1945), working with *Pituophis* in Nebraska, recovered 12 bullsnakes that had been marked earlier in the same year. Eleven of them had moved less than 300 yards, while the other, a second year female, traveled 1.5 miles from June to September. Two large adults were released at a lake 3.5 miles from the place of collection and were recovered there 2 years later. Either the homing instinct is not developed in this species, or the distance was too great, or the new environment was too favorable for homing to occur.

Travels Beyond the Home Range.—It is interesting that in most of the studies there appear one or more records of snakes traveling long distances despite having been released where collected. Errors of marking or releasing may account for some of these departures from the home range but surely all of them cannot be so explained. From our own data it is seen that a *Coluber* was found 1.1 miles from its first locality. Blanchard and Finster mention a *Thamnophis* journey of 1.5 miles. Noble and Clausen found some of their *Storeria* about three-quarters of a mile away from the place of original collection. Imler cites a *Pituophis* that traveled 1.5 miles. Horn and Fitch apparently had enough instances of extensive wanderings to persuade them that there were no home ranges despite the highly sedentary tendencies of their snakes. In each of these studies, with the possible exception of that of Horn and Fitch, the long trips are exceptional and represent a type of behavior superimposed upon the animals' relationship to the home range. It is this which we believe is largely responsible for the authors' failure to recognize that serpents have home ranges, despite the fact that important parts of their data suggest the presence of such ranges.

Wanderings beyond the accustomed area certainly confuse the issue as to the presence of home ranges and complicate the determination of range sizes, but such travels are natural and to be expected. At times a large part of a species population may be transient. Blair (1940a) found that at certain

periods as much as 16 per cent of a *Microtus* population consisted of transients. Storer, Evans and Palmer calculated that 16 to 40 per cent of a *Peromyscus maniculatus* population were transients and that in *Peromyscus boylii* the non-residents equalled or exceeded the residents in numbers throughout much of the year. Most other careful studies of small mammals have not revealed such high proportions of non-residents.

The local movements of rodents have been discussed in detail by Storer, Evans and Palmer, Burt (1940), and Blair. They demonstrate that there is constant shifting, readjustment of ranges and replacement of individuals, but that after an individual is once established it usually makes but slight, gradual changes in its range. In view of this fact, it is of interest to consider the various categories of transients among wingless, terrestrial vertebrates. Our list is no doubt incomplete, but it demonstrates that much movement outside the usual radius of activity can and does occur without violating the home range concept. The examples are drawn chiefly from work on rodents because they are definitely known to have home ranges and because intensive field studies have been made on them.

1. Brief trips are made from the home range to a distance of several home range diameters. Several instances of this behavior in rodents are given by Storer, Evans and Palmer. Probably these excursions occur more frequently than we suspect, but as Burt has said, "Occasional sallies outside the area, perhaps exploratory in nature, should not be considered as in part of the home range."

2. Some animals have more than one home range. Many large mammals have summer and winter ranges between which they migrate. Certain non-migratory animals are known to use different areas, separated by no great distance, depending on their seasonal suitability. Also, a home range might be of two nearby parts separated by a region ecologically unfit for the species.

3. Animals are induced to leave their home ranges temporarily by the local prevalence of special foods, in search of mates, egg-laying sites, hibernating quarters. Under favorable conditions all these requirements can be met within or immediately adjacent to the usual range, but at times long journeys from the habitat are necessary.

4. The established home range may be abandoned in favor of a new one for no apparent reason. The new home may be very near the old one or far removed. Blair (1940a: 158; 1940b: 280, 283, 295), Nicholson (1941: 209) and Storer, Evans and Palmer (p. 178) have found this to occur. Blair (1940b: 280) noted that certain deer mice left the study area but returned to it after 2 to 4 months. The reason for this movement and the whereabouts of the animals in the meantime are not known.

5. Animals are frequently forced from habitats that are altered by drying, burning, flooding, cultivation, successional changes in vegetation, overpopulation or impoverishment. Cyclic diminution in the numbers of prey cause extensions of predator ranges. Environments may vary sufficiently to promote animal wanderings without the cause being apparent to the observer. For example, in terrestrial snakes overpopulation enough to encourage the emigration of some individuals would be discernible to the student only after long experience with the species.

6. Young animals frequently travel about awhile before finding a suitable, unoccupied home site (Burt 1940: 28). The young may be well grown before the wandering begins. Among mammals the juveniles of some species remain with the mother until the next young are to be born, and in certain species even longer. If the food habits of the young are different from those of the adults the period of exploration may be delayed until the young and adults are competing for the same foods.

7. Old or weakened individuals may be displaced by stronger, more aggressive animals.

8. If an animal is removed from its home range by man, flood, or other agents it will usually wander extensively or attempt to home. Cagle has demonstrated these phenomena for aquatic turtles. Box turtles will home for considerable distances whether moved away by man or flood. The scattering of snakes and deer mice after being artificially displaced and concentrated has been well illustrated by Blanchard and Finster, Blanchard (1937), and Blair (1940b). Transplanted game animals ordinarily disperse widely, some traveling great distances.

9. A few individuals may be habitual wanderers. Nervous disorders could upset an animal's relationship to its home range.

10. Sheer "wanderlust" has been suggested as the cause of animal travels, but no useful purpose is served by describing animal behavior with a term that could be used to characterize any wandering of unknown cause.

Certain locations have a far greater percentage of transients than others. For example, the headquarters part of the Patuxent Refuge, an area of lawns, laboratories and residences, is visited by snakes and salamanders of most local species but few of them live there. The Refuge junkyard is a good collecting spot for small snakes but produced no repeats from 1943 through 1945. It is to be expected that hedgerows and watercourses, particularly in arid or cultivated country, would serve as lanes of travel and hence have a higher percentage of wanderers. Consequently, home ranges can best be determined in natural, continuous habitats.

ACKNOWLEDGMENTS.—The specimens that form the basis of this paper were collected by many individuals now or formerly at the Patuxent Refuge. The collections were often made at the cost of considerable inconvenience. For this indispensable assistance we are sincerely grateful. Special mention should be made of Mr. Robert E. Stewart and Mr. Chandler S. Robbins, who made particularly useful contributions to the subject. Mrs. Lucille F. Stickel has aided materially by discussion of the principles involved and the suggestion of pertinent references.

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FISH AND WILD LIFE SERVICE, PATUXENT REFUGE, LAUREL, MARYLAND.

Herpetological Notes

BONE-MAKING MATERIAL FOR TURTLES.—At some time or other probably most museum curators receive enquiries from persons who complain that juvenile *Chrysemys* or *Pseudemys* kept through the winter in an aquarium, have carapaces that are softening towards the periphery. Absence of ultra-violet rays appears to be a contributary cause, but once the condition has developed I know of no *cure*.

I believe that the condition can be prevented from developing by placing lumps of plaster-of-paris in the aquarium, for we have been successful in rearing sturdy second and third generations of smooth-clawed frogs (*Xenopus l. laevis*) here, whereas those raised elsewhere commonly suffer from rickets, or something resembling it. As a lump of plaster the size of a human fist will dissolve away in the course of a month or two, it will be found necessary to renew it from time to time.

In this connection I should like to direct attention to a communication (Journ. E. Africa Nat. Hist. Soc., 1945, 18: 163) by P. R. O. Bally of the Coryndon Memorial Museum, Nairobi. Mr. Bally observed a captive leopard tortoise (*Testudo pardalis babcocki*) take up a chicken bone twice as long as its own head, and swallow it whole. The bone was devoid of meat. Some days later the reptile was found nosing and pushing around a much larger bone. When Bally smashed this bone the tortoise seized the jagged splinters, one of which was an inch and a half long, and swallowed them one by one till all were gone. Thereafter the reptile's vegetarian diet has been supplemented by a daily ration of bone splinters upon which it appears to be thriving.—ARTHUR LOVEIDGE, *Museum of Comparative Zoology, Cambridge, Massachusetts.*

DEFENSIVE USE OF PAROTOID SECRETION BY *BUFO MARINUS*.—Near Hebbronville, Texas, September 14, 1946, the writer tossed a female *Bufo marinus* of some 90 mm. body length into a pond. The female began swimming toward a small island about 50 feet away in the center of the pond. As the toad neared the island it was seized just behind the insertion of the left forelimb by a turtle, probably *Kinosternon*, of approximately 5 inches carapace length. The toad responded by inflating its lungs so that it floated high in the water. A struggle followed in which the turtle endeavored to pull the toad under the water, while the toad made an effort to swim away. With the turtle hanging on, the toad swam in circles and made no progress. After several minutes the turtle succeeded in pulling the toad under the water. In a short time, however, the toad reappeared at the surface, and, although in considerable difficulty because of the left lung protruding through the wound made by the turtle, proceeded without further molestation to the shore of the pond. The turtle was seen swimming in the opposite direction. Examination of the toad showed the left parotoid gland thickly covered with white secretion. The right gland showed no secretion. While the evidence is not conclusive that the parotoid secretion was responsible for release of the toad by the turtle, it seems likely that this was the case.

Chen and Chen (1933, Jour. of Pharmacol. and Exp. Therapeutics 47(3): 281–293) found no instance of the parotoid secretion of *Bufo marinus* being "squirted" out when these toads were handled. However, a recent experience of the writer indicates that the secretion may be forcibly ejected. While engaged in laboratory experiments, a male *Bufo alvarius* was placed on the back of a male *B. marinus*. The male *B. alvarius* vigorously clasped the *B. marinus* just back of the parotoid glands; the parotoid glands were not touched. The male *B. marinus* immediately ejected secretion from the left parotoid gland, the secretion striking the investigator in the mouth some 15 inches away and producing a bitter taste. There was no question as to the act of ejection as the investigator was looking directly at the toad at the time. However, to check on the matter, the same male *B. marinus* was subsequently picked up by hand and seen to eject a droplet of secretion some 4 or 5 inches into the air.—A. P. Blair, *The American Museum of Natural History, New York, New York.*

PARTIAL HERMAPHRODITISM IN THE COMMON INDIAN FROG, *RANA TIGRINA*.—Varying degrees of hermaphroditism are quite common in frogs, or even uniformly developed in large populations, and have also been recorded in the Indian frog by Bhattacharya and Das (1920, Jour. and Proc. Asiatic Soc. Bengal, New Series, 16, no. 7: 293–296) and Bhaduri (1929, Jour. and Proc. Asiatic Soc. Bengal, 24, no. 4: 484–499). I found an additional specimen in the summer of 1945, and noted certain obvious differences from the previously recorded cases. It was the only specimen exhibiting sexual anomaly in more than 2000 examined during class dissections over a period of three years.

This specimen had persistent oviducts but no traces of ovaries. The testes were apparently functional (histological sections were not made) on both sides, but exhibited slight asymmetry—the left being better developed. The measurements were: right testis, 7.5 mm. long and 1.0 mm. wide; left testis, 8.2 mm. by 1.5 mm. Otherwise the gonads and accessory sexual organs were similar for both sides as follows: testes, yellowish in color, but not as dark as in normal males; vasa efferentia, well developed; ureters, not prominently enlarged to form seminal vesicles (Bhattacharya and Das, *op. cit.*, noted well formed seminal vesicles); oviducts, well developed, very much convoluted (greatest diameter, 0.5 mm.) and terminating posteriorly without cloacal connection; uteri, not distinct.

This individual had normal color and externally resembled other adult male frogs of the season. It measured 100 mm. in snout to vent length. It had male nuptial thumb pads and well developed vocal sacs.—Brahma Swarup Kaushiva, *Department of Zoology, University of Michigan, Ann Arbor, Michigan.*

RANGE EXTENSIONS OF THREE REPTILES IN COLORADO.—During the spring and summer of 1946, I had occasion to make several collecting trips in the northern part of Colorado, during the course of which three species of reptiles were collected from localities that constitute extensions of their known range.

Urosaurus ornatus wrighti (Schmidt).—The most northerly record of this species in Colorado was made by Ellis and Henderson (1913, Univ. Colorado Studies, 10: 65), who reported on a specimen from 4 miles west of Meeker, Rio Blanco County. On June 20, 1946, I collected 13 specimens from Hell's Canyon, at an elevation of 5100 feet, and 4 more were collected on June 21, 1946, from a small arroyo 6 miles west of Hell's Canyon, at an elevation of 5400 feet, in Moffat County. These records constitute a northerly extension of the range in the state. In keeping with Smith's summary of the behavior of this species (Smith, 1946, Handbook of Lizards: 275), these Moffat County specimens were all caught on the vertical rock walls of the canyons in which they were found. Preference is shown for cliff faces whose bases are shaded by bushes. When at rest, the lizards often orientate themselves on the rock so as to lie within the shadow cast by a stem or leaf. If startled, they climb as high as 40 feet up the cliff face. Their movements over the rock are quick but sure, with numerous pauses. In this respect they differ from most ground lizards, which rush madly for cover on being alarmed.

Uta stansburiana stansburiana Baird and Girard.—The most northerly Colorado record of this species was made by Cary (1911, North American Fauna No. 33: 26), who collected specimens at DeBeque, Mesa County. Six specimens collected on June 21, 1946, in a small arroyo 6 miles west of Hell's Canyon, at an elevation of 5400 feet in Moffat County, constitute an 80-mile northerly extension of the range of this species. These specimens were associated with *Urosaurus ornata wrighti* but unlike the cliff-inhabiting *Urosaurus*, the *Uta* were found among the boulders and rubble at the bases of the cliffs or in the vicinity of large rock outcrops of the less precipitous slopes of the small arroyo. The color pattern of these specimens is like that described by Smith (1946, *loc cit.*: 278) for Utah and eastern Nevada forms. The dorsal surfaces of both sexes are a light pinkish brown without stripes or dark marks. Scattered on this ground color are small light blue spots which are more distinct laterally than medially.

Masticophis taeniatus taeniatus (Hallowell).—Two adult females of this species were caught at 11:00 A.M., on June 20, 1946, near the Yampa River 6 miles west of Hell's Canyon, Moffat County, at an elevation of 5400 feet. Carry (1911, North American Fauna, No. 33: 27) recorded a specimen from Morris, west of Rifle, Garfield County. The Moffat County station represents a northerly range extension of 70 miles. Both specimens were taken from beneath 2-foot high bushes in a small arroyo in which flowed a little spring. The arroyo itself was rich in desert vegetation in contrast to the nearly barren surrounding country sparsely covered with a scant growth of sage. The snakes were within 10 feet of one another on a small bench at the base of a 40-foot cliff. On the ground and in the bushes near by 5 molted skins were found which strongly suggested that the locality was a den more or less permanently inhabited by the snakes. Both specimens were gravid, each carrying 4 large eggs that could be easily recognized by their outlines through the abdominal walls. One of the eggs, when removed and examined, was 63 mm. long and 14 mm. in diameter and covered with a heavy membranous shell irregularly studded with small sharp rugosites about 1 mm. apart. No embryo was found in the egg, which at this stage was made up of an irregular yolk mass and an exceptionally large amount of albumen, constituting about a third of the volume.—T. Paul Maslin, *Colorado A. & M. College, Fort Collins, Colorado.*

NOTES ON THE SPADEFOOT TOAD IN CAPTIVITY.—The finding of breeding spadefoot toads, *Scaphiopus holbrookii holbrookii* (Harlan) in Essex County, Massachusetts, in 1937, was reported by the writer (1937, Bull. New England Mus. Nat. Hist., 85: 12). The boys who collected them collected also a number of newly transformed toadlets as well as the several adults, all of which were turned over to the writer. About 13 of the tiny toads were put into a glass aquarium with a few inches of soil on the bottom, in which they were left for two weeks with no other attention than keeping the soil damp. The first food was offered them on July 16 and they

fed eagerly. The food then offered, black and green aphids, became their staple diet for that first summer, together with the nymphs of tingitid bugs collected from hawthorn trees. Tiny earthworms were also accepted. Measurements of body length, taken first on July 17, varied from 10 to 15 mm. One of the largest of the toadlets tried to dig in, in the approved spadefoot manner, on July 18, but the earth seemed to be too hard. As a rule the tiny toads contented themselves with crouching in the irregularities of the soil and hiding under the loose bits. For no discoverable reason, the toads soon began to die off. As far as could be told, all appeared healthy and gave the same reaction to the care and environment but one after another was found dead. By November 17, 1937, only two were left; these measured 2.0 and 2.2 cm. One of these two spadefoots escaped during the summer of 1939, before the writer realized that they were capable of surmounting the sides of the aquarium. They were photographed together on July 4, 1939, at which date they measured 4.1 cm. The other toad is still alive after nine years in the writer's possession, and in May, 1946, measured 6.7 cm. and weighed 46.65 gm.

Certain data noted during the nine years that the toad has been kept may be of interest. At first, food was offered during the daytime only; it was taken eagerly and the juvenile toads showed little aversion to light. By March, 1938, however, the toads were living a typical burrowing life, coming to the surface only at night and showing marked aversion to light. Under such conditions, it was not easy to keep accurate records of the quantity of food eaten. Insects introduced into the cage frequently disappeared, but it was not certain that they were eaten. Earthworms, unless taken by the toads at once, burrowed and escaped, for these toads do not feed at all under the earth. Whenever possible the feeding was supervised and the desire to do this probably resulted in less food for the toad, since the writer's nocturnal habits are not nearly as well established as the toads'. The sensitiveness to light often resulted in retreat into the hole from which recent emergence had taken place. Other than that, there has been no evidence of use of a regular burrow.

Probably most insects would be accepted by spadefoots but the menu offered this toad contained: house flies, earthworms, meal worms and beetles, lady bugs and moths. There seemed a preference for the meal worm beetles over the worms themselves and moths were taken with great avidity. At the present time, wasps are taken, the only species so far offered being the black and yellow mud dauber, *Sceliphron caementarium* (Drury). In times of insect shortages the toad has accepted small pieces of liver, horsemeat and fish spawn.

At times the toad has appeared very bloated and sluggish and with poor appetite. Such conditions seemed to correct themselves but the presence of another toad (*Bufo valliceps*) of about the same size seemed to stimulate feeding activity by providing competition. Removal to a large, out-door aquarium during the summer months was beneficial. During the years there have been times, at irregular intervals and not, apparently, depending on seasonal or any other outside influence that could be determined, when the toad did not appear above ground for several weeks at a time. Sometimes it would emerge but show no interest in food. The lyre-shaped pattern on the back was first noticed Nov. 18, 1938. During the past year or so the toad has shown greater tolerance for light and has even fed in the morning.

Although no experiments have been tried, there has been no indication of a definite stimulus to emerge. The earth-filled terrarium, in which the toad lives, is kept at normal room temperature (65°–70° F.) with some fluctuations, during the winter; during the summer, before the toad was put in the out-door terrarium, the temperature varied, more or less, according to the weather. When the animal is out of doors, neither temperature nor humidity seem to control the emergence.

Following a long period during which there has been no sign of the toad, a very thorough wetting of the earth seems to induce emergence. One thing seems fairly certain: emergence does not take place during the daylight hours. Such greater tolerance for light as was mentioned as being evident this past year is indicated by the toad's remaining above ground when either the electric light is turned on in the room or after day has dawned. But emergence seems to take place always after dark.—ISABEL HOOPES, *Rowley, R.F.D., Massachusetts.*

NOTES ON THE RANGES OF SOME NORTH AMERICAN SALAMANDERS.—In the winter of 1945-1946 and the summer of 1946, the writers examined 4,059 specimens of salamanders deposited in the Museum of Natural History of the University of Kansas, as of January 31, 1946. Study of these specimens yielded extensions in the known ranges of several species, as defined in Stejneger and Barbour's *Check-List of North American Amphibians and Reptiles* (5th edition, 1943) and Bishop's *Handbook of Salamanders* (1943). The new records are as follows:

Cryptobranchus alleganiensis (Daudin).—No. 19472, collected on April 24, 1935, by C. W. Hibbard at Green River, Mammoth Cave ferry, Edmonson County, Kentucky. This record extends the known range of the species to the upper Green River valley, 50 miles southward of the Ohio River where the species has previously been collected.

Ambystoma jeffersonianum (Green).—No. 4599, collected in July, 1911, by J. Dudley near Columbia, Boone County, Missouri. This is the first known occurrence of the species for central Missouri. Nos. 2642-2643, collected on July 15, 1926, by T. E. White and E. H. Taylor at Perryville, Decatur County, Tennessee. This is possibly the first recorded occurrence for the species in Tennessee.

Ambystoma tigrinum nebulosum Hallowell.—No. 19873, collected in the autumn of 1935 by M. Allison from a locality 12 miles north of Mt. Hope, Prescott National Forest, Yavapai County, Arizona. This is the southwesternmost record for the subspecies. No. 5167, collected on June 16, 1928, by E. H. Taylor at Therma, Colfax County, New Mexico. This record establishes the occurrence of the subspecies east of the Rio Grande, and well into what is considered the range of *Ambystoma tigrinum mavortium* Baird. The following records extended the known range of the subspecies into west central New Mexico: Nos. 15558-15559, collected on July 27, 1929, by E. H. Taylor and Wright at Santa Fe, Santa Fe County; No. 22756, collected on June 24, 1928, by R. H. Beamer at Jemez Springs, Sandoval County; Nos. 15556-15557, collected on July 31, 1929, by E. H. Taylor and Wright at Inscription Rock, Valencia County, and No. 5168, collected on June 24, 1928, by E. H. Taylor at Albuquerque, Bernalillo County.

Ambystoma tigrinum slateri Dunn.—No. 21836, collected on August 12, 1940, by J. Tihen in Meade County, Kansas. The first known occurrence of the subspecies in Kansas. The nearest station previously recorded is in south central Nebraska, some 300 miles north.

Eurycea bislineata bislineata (Green).—Nos. 21565-21571, collected on October 13, 1940, by O. W. Tiemeir, in Berrien County, Michigan. This record extends the known range of the subspecies into extreme southwestern Michigan.

Eurycea bislineata cirrigera (Green).—Nos. 21645-21656, collected on April 14, 1941, by O. W. Tiemeir at Reel Foot Lake, Lake County, Tennessee. This record extends the known range of the subspecies westward into extreme western Tenessee.

Eurycea lucifuga Rafinesque.—Nos. 2614-2616, collected on July 14, 1926, by T. E. White and E. H. Taylor at Perryville, Decatur County, Tennessee. This record extends the known range of the species westward into western Tennessee.—MANUEL MALDONADO-KOERDELL and IRWIN LESTER FIRSCHEIN, *Museum of Natural History, University of Kansas, Lawrence, Kansas.*

AN ALBINO EASTERN GARTER SNAKE FROM PENNSYLVANIA.—An albino eastern garter snake, *Thamnophis sirtalis sirtalis* (Linnaeus), was found in a wooded area in Riverview Park, Pittsburgh, Pennsylvania, where normal specimens of this species are numerous, in the spring of 1941. The snake was kept alive at the Park's Trailside Museum until late autumn, when it died. Its normal cagemates exhibited no particular interest in it, and the behavior of the albino was typical of the species. In life the ground color was off white, the mid-dorsal and lateral stripes yellowish cream, the venter unicolor white, and the eyes pink. A kodachrome slide was made from the living snake. The specimen, a female with an incomplete tail, has a total length of 551 mm. and a tail length of 106 mm. It has been deposited in Carnegie Museum (CM 26,259).—A. J. BARTON, *Highland Park Zoological Garden, Pittsburgh 6, Pennsylvania.*

RATES OF TEMPERATURE INCREASE IN THE DINOSAURS.—In a recent paper on temperature tolerances in the alligator, Colbert, Cowles and Bogert made some inferences, as based upon their crocodilian studies, as to the probable rate of temperature increase in some of the extinct dinosaurs.

> . . . the rate of temperature increase in the small alligator is 1°C. every minute and a half, while the rate of temperature increase in the larger alligator, an animal 260 times as great in body mass as the small alligator, is about 1°C. every seven and a half minutes. Continuing this line of reasoning, it would seem probable that in an adult ten-ton dinosaur, say an animal with a body weight of about 9 million grams, the rate of temperature rise would be very much slower than in the large alligator. Indeed, if the same difference in temperature rise as existed between the large and small alligators were applied to the dinosaur (an animal 700 times greater in body mass than the *large* alligator) then one may suppose that it would have taken more than 86 hours to raise the body temperature 1°C. in the adult extinct giant.[1]

In recent letters to the authors, Professor A. D. Moore of the University of Michigan, and Professor Angus M. Woodbury of the University of Utah have (independently of each other) made objections to the statement quoted above. Both of these authorities feel that the figure of 86 hours, supposed as necessary to effectuate a rise of 1°C. in the temperature of the extinct dinosaur, is much too long.

The figure given in our paper was reached by a simple process of extrapolation. We reasoned that if it took 7.5 minutes for a 1°C. temperature rise in an alligator weighing 13,000 grams it would require 700 times as long a period for a similar temperature rise in a dinosaur 700 times as heavy as the alligator. This, by a simple process of multiplication gives a figure of about 86 hours.

Professor Moore feels that the above method for obtaining the probable temperature rise in the dinosaur is incorrect. He argues that the relationship between surface area and mass must be taken into account. Therefore, in light of this consideration, the time for a given rise in temperature varies directly with the cube root of the weight. "The cube root of 700 is 8.9. The prediction then is, for the dinosaur, 7.5 minutes times 8.9, or 67 minutes."

Professor Woodbury comes to a similar conclusion, based upon weight, surface and heat capacity relations. His conclusion may be defined by the following formula:

$$\frac{\text{Weight}}{\text{Surface}} = \text{density} \times \text{length} \times \text{shape factor}$$

According to Professor Woodbury, the values derived for a 9,000,000 gram dinosaur vary from 66 to 81.5 minutes.

The authors willingly admit that their original figure may have been incorrectly derived and that it probably is much too large. On the other hand we feel that the methods utilized by Professors Moore and Woodbury, while probably more valid for purely physical factors, are not necessarily completely reliable for such complex physiological phenomena as are dealt with in a living organism. It is our feeling that, while a figure of 86 hours for a 1°C. temperature rise in the extinct ten-ton dinosaur may be much too long, the figure of 66 to 81.5 minutes may err in the other extreme and be much too short.

There are many intangibles to be taken into account in a consideration of a problem such as this one. The alligator or the dinosaur is more than a cylindrical, inanimate mass of definite dimensions. Physiological processes must be considered and these include respiration and attendant heat loss through evaporation in the nasal and buccal areas, also heat exchange in the inhaled air mass, especially as the body warms and approaches or exceeds the temperature of the inspired air. Heat transfer to the ground, especially when the animal is in the prone position, has been shown to be a very important factor in modern reptiles and there is little reason to doubt its effectiveness in archaic types. Rates of blood circulation increase with rising body temperatures; thus heat distribution to areas of heat loss will be involved in rate of temperature rise. In addition to these factors, the thermal characteristics of the plates or scales of the skin, heat loss by means of insensible water vapor, changing albedo and other traits are necessarily at work in modifying the rate of temperature changes.

From our standpoint it seemed that the inevitable errors involved in any method of calculation would be lessened by means of simple extrapolation from data obtained from

[1] Colbert, Edwin H., Raymond B. Cowles and Charles M. Bogert. 1946, Bull. Amer. Mus. Nat. Hist., 86: 365–366.

the animal. The only reasonably sure check on this interesting problem, we feel, would be actual experimentation with a living reptile of truly large size—in other words, with one of the largest of the known crocodilians, such as the gavial or the salt-water crocodile. Obviously such a procedure is not possible at the present time.

In the meantime, it is safe to say that a temperature rise of 1° C. in a ten-ton dinosaur probably required something more than one hour and something less than several days. It is our opinion, however, that several hours may have been required for such a temperature rise.

What we would all agree to, and this is the point that was being emphasized in the publication cited above, is the fact that temperature fluctuations in the larger dinosaurs must have been much less abrupt than they are in most of the recent reptiles. Therefore body temperatures in the large dinosaurs must have been relatively constant, with the result that these animals may have had some of the physiological advantages that characterize birds and mammals. Would this explain, in some degree, the long period of dominance enjoyed by the dinosaurs?—EDWIN H. COLBERT, RAYMOND B. COWLES, and CHARLES M. BOGERT, *The American Museum of Natural History, New York City* and *The University of California at Los Angeles, California.*

THE ESTABLISHMENT OF *TRIONYX SINENSIS* IN HAWAII.—Reports of the existence of a soft shell turtle on the Island of Kauai, Territory of Hawaii, are now verified by a specimen from the Fish and Game Warden for the Island of Kauai received by the Division of Fish and Game in Honolulu early in December of 1945. In the course of an inspection trip to Kauai in November, 1946, I obtained another soft shell turtle from the Kealia River, from which the first specimen had come.

The two specimens were identified as *Trionyx sinensis* Wiegmann. Measurements and weights of these turtles are given below:

	SPECIMEN OF DECEMBER 1, 1945	SPECIMEN OF NOVEMBER 22, 1946
Sex	♂	♂
Carapace length	291 mm.	330 mm.
Carapace width	230 mm.	228 mm.
Plastron length	228.5 mm.	239 mm.
Shell depth	81 mm.	84 mm.
Head width	51 mm.	
Snout length (from upper lip)	7.5 mm.	
Snout length (from eye)	27.5 mm.	
Weight	—	3750 gm.

A soft shell turtle, taken by means of a thrownet, was reported by the Kauai warden to have weighed 18.5 pounds.

The range of this species on Kauai, as obtained from local information, is along the eastern side of the island from about Lihue on the south to the Kealia River drainage on the north, a distance of some 10 to 12 miles, and from the upper boundary of tidewater into the upper, rapidly flowing mountain stream portions of the rivers concerned, which may be a matter of 7 or 8 miles.

This species is highly prized as food by Orientals, especially the Chinese, and since the beginning of World War II, when the supply from the Orient was stopped, this small stock on Kauai has been the only source of supply for Hawaii. Hence it has been vigorously exploited, and it may be surmised that only the secretive habits of *T. sinensis* have prevented the early disappearance of the species from that island. The price during the war reached six dollars per pound; the present price is about one dollar per pound.

On November 29, 1946, both turtles are alive and on exhibition at the Waikiki Aquarium.—VERNON E. BROCK, *Director, Division of Fish and Game, Honolulu, Territory of Hawaii.*

KINOSTERNON SUBRUBRUM SUBRUBRUM IN THE CHICAGO REGION.—A male specimen of the common mud turtle, *Kinosternon subrubrum subrubrum* (Lacépède), was taken in a small meadow pond on May 17, 1946, near Mt. Ayr, Newton County, in northwestern Indiana. The measurements of this turtle are as follows:

Maximum length of		Maximum width of	
Carapace	92 mm.	Carapace	72 mm.
Plastron	87 mm.	Anterior lobe of plastron	48 mm.
Bridge	17 mm.	Posterior lobe of plastron	44 mm.
Interhumeral suture	15 mm.	Maximum height	40 mm.
Interfemoral suture	4 mm.		

Schmidt and Necker, in their list of amphibians and reptiles of the Chicago region (1935, Bull. Chicago Acad. Sci., 5: 57–77), Schmidt, in his leaflet on the turtles of the Chicago area (1938, Chicago Nat. Hist. Mus., Popular Ser., no. 14), Necker, in his supplementary list of 1939 (1939, Bull. Chicago Acad. Sci., 6: 1–10), and Pope, in "Amphibians and Reptiles of the Chicago Area" (1944, Chicago Nat. Hist. Mus.), have all failed to note the occurrence of *Kinosternon s. subrubrum* in the "Chicago Area" as defined by them. Stejneger and Barbour, in the "Checklist of North American Amphibians and Reptiles," 5th Ed., 1943 (p. 194), give the range of this species as "Eastern United States from Connecticut south to the northern counties of Florida, west to Indiana, Illinois, and Tennessee."

Grant records this species from Porter and Starke counties, (1935, Amer. Mid. Nat., 16: 798–800), and from Jasper County of the Jasper-Pulaski State Game Preserve, (1936, Proc. Ind. Acad. Sci., 45: 323–333).—W. T. STILLE, *Chicago, Illinois.*

THE AQUATIC HABITS OF *CNEMIDOPHORUS SEXLINEATUS.*—During the seasons of 1941–3, the six-lined racerunner, *Cnemidophorus sexlineatus* (Linnaeus), was observed to take refuge under water, as noted by Dillon and Baldauf. (COPEIA, 1945: 174).

This species of lizard, abundant in the dune areas of northern Indiana, frequently occupies the sandy slopes adjacent to ponds and marshes, which are very numerous in this region. In the company of Edward J. Lace and Edward J. Tierney, attempts at mass capture of individuals of this species, by routing them down the slopes toward the water with noise and violent activity, were followed by the unexpected disappearance of the lizards into the water. With several additional experiences collecting methods were revised, but an occasional specimen would avoid capture by entering water on most of the succeeding collecting trips.—W. T. STILLE, *Chicago, Illinois.*

AN INEXPENSIVE SNARE FOR WATER SNAKES.—While engaged in studies on osteogenesis in *Natrix* during the summer of 1940, 1941, and 1942, I made numerous trips into the field in quest of these water snakes. I tried several methods of capturing them. The two types of "snake sticks," one with an iron hook and one with a leather loop, were first used. The difficulties encountered using such sticks for specimens in water are obvious.

To remedy the difficulties encountered I devised a snare made from an old pair of three-prong sterilizing forceps attached securely, by one scissor grip, to the end of a light but strong 12-foot cane pole. To the scissor grip not attached to the pole a lead weight was fastened for the purpose of keeping the prongs open. A heavy cotton cord was run from this loose scissor grip through guides provided along the pole to its base, to control the grasping prongs. This snare proved excellent for both *Natrix* and *Agkistrodon.* The best method of capturing large water snakes is to grasp them about mid-body. Such a three-prong sterilizing forceps snare will take specimens up to 4½ inches in diameter. These forceps can be found discarded around most hospitals. The same type of snare can be made from a castaloy versatile clamp (Fisher Scientific Company), which will take specimens up to 3¼ inches in diameter.—MALCOLM A. FRANKLIN, *Department of Anatomy, School of Medicine, University of Mississippi.*

A NOTE ON LONGEVITY OF AMPHIBIANS AND REPTILES IN CAPTIVITY.—So far as I know there has been no compilation of longevity records of amphibians and reptiles kept in captivity in the various zoos and other collections in the United States. It is hoped that the publication of the following list from the San Diego Zoo will bring correspondence from others with better records. We intend to continue keeping these records and will be glad to get information about any snake kept in captivity for more than 10 years.

We have 5 year-or-more records for 115 snakes of 51 species and subspecies. Of these 80 specimens of 42 species and subspecies are still alive—20 per cent of them were born here. This would make too long a list and it would seem best to list no specimen with a captivity record of less than 10 years.

With the exception of 3 snakes (marked with an *) all the following specimens are still alive. All were received as adults except the Galapagos tortoises and the *Crotalus ruber*. Figures are to the nearest month and are as of February 1, 1947.

Specimen and Species	Years	Months
Bufo marinus	15	0
Conolophus subcristatus (2 specimens)	15	1
Dipsosaurus dorsalis dorsalis	10	0
Ophisaurus apodus (2 specimens)	24	0
Python curtus curtus	11	0
* *Python reticulatus*	10	9
Python reticulatus	10	9
Python molurus bivittatus	10	11
Python molurus bivittatus	10	9
Epicrates cenchris maurus	10	3
Lichanura roseofusca roseofusca	10	7
Masticophis flagellum testaceus (2 specimens)	10	3
Pituophis catenifer annectens	10	5
* *Lampropeltis getulus brooksi*	10	0
Lampropeltis getulus californiae	10	2
Naja nivea	10	0
Naja melanoleuca	18	4
Agkistrodon mokeson mokeson	10	8
Crotalus atrox (2 specimens)	10	8
Crotalus atrox (2 specimens)	10	3
* *Crotalus ruber*	10	1
Crotalus viridis oreganus	10	0
Macrochelys temminckii (2 specimens)	20	3
Chelodina longicollis (8 specimens)	21	8
Testudo sp. (Galapagos Islands)	18	8

C. B. Perkins, *Zoological Society of San Diego, San Diego, California.*

RECORD FOR *ANEIDES AENEUS* IN VIRGINIA.—Dunn (1926, Salamanders of the Family Plethodontidae: 208) records *Aneides aeneus* from Virginia on the basis of a single specimen from "dolomite caves of Cumberland Mts., Lee County." In his 1936 list of Virginia amphibians and reptiles (mimeographed, Haverford, Pa.: 1–5) Dunn again cites only this Lee County record. Thus there have apparently been no other specimens of *A. aeneus* reported from the state, although Bishop's distributional map (1943, Handbook of Salamanders: 329) would indicate otherwise, since a large area of southwestern Virginia is included in the range of this salamander. Presumably the inclusion of this area, from which no specimens appear to have been collected, was on the basis of its continuity with the general range of the species. A specimen of *A. aeneus* recently collected by the writer from the area in question was found on July 5, 1946, near Hayter Gap in Clinch Mountain, Washington County, at an elevation of about 2500 feet. It was discovered between the intact sapwood and soft decomposed heartwood of a fallen chestnut stump in woods at the edge of a dirt road. Physiographically this locality is in the Tennessee section of the Valley and Ridge province of the Appalachian Highlands and is about 100 miles ENE of the Lee County record.—J. A. Fowler, *Biology Department, Sidwell Friends School, Washington, D.C.*

Ichthyological Notes

A POSSIBLE EXPLANATION OF THE "RESERVE" DENTITION OF *HYDROCYON LINEATUS* AND ALLIED FISHES.—By the courtesy of the Game Warden of the Kruger National Park I have been able to study the dentition of *Hydrocyon lineatus* from the Sabi River, latitude 24° 30′ S., longitude 31° 55′ E., and, as some of the specimens were recently captured with the gum not yet hardened, I observed the movements of the obscure unerupted teeth of this fish before hardening had rendered this impossible.[1]

In the specimens I have examined there are, on each side of the upper and lower jaws, from five to seven sharp, erupted teeth, fixed in an upright position and suitably spaced for interlocking. Larger specimens have been reported, and beautifully illustrated, showing eight teeth on the premaxillary and dentary bones but giving no sign of tooth-formation suggestive of succession. Much of the tooth substance appears to consist of the same material as that of the ligamentous union of the tooth at its base, and growth of each tooth would appear to continue, as Professor Gregory observes, "by the extension of their bases away from the tips," as I have described in the African crocodile. Foramina for nerve and blood supply are visible on the outer side.

Injury to the erect teeth is not uncommon and a stump, when broken off, remains united to the jaw by ligament which can be dissected away from the underlying fossa, the latter extending deep into the jaw below the erect tooth just behind it. After stripping off the gum a similarly sharp tooth is revealed lying in each fossa and directed towards the gullet. This latter tooth is attached to the side of the fossa so that it can be detached, although it moves freely in any direction from side to side. In life these unerupted teeth may well serve to steady the soft overlying gum as it moves when food and water are forcibly ejected from the mouth, and it may well be related to the fish's characteristic feeding habits.

The tip of a backwardly directed tooth is often situated behind the exposed tooth immediately in front of it but, once it is freed from its attachment, the tooth can be guided along the fossa until it has taken the place of the erect tooth at the uppermost extremity of the fossa; there it is found to be almost as large as one of the erect teeth. There is, however, no evidence to show that such a movement has taken place under natural conditions. A considerable distance exists between an erect tooth and its corresponding unerupted tooth and there is nothing to suggest that the latter in any way hastens the shedding of an erupted tooth. If the backwardly directed teeth are for replacement they should face vertically.

Neither radiographs nor dissection reveal other tooth-formation or dental germs at the base of either set of teeth to support the conjecture of replacement, and one concludes that the two rows of teeth are for distinct purposes, both remaining in their distinctive positions for life, one fixed and erect, the other movable beneath the gum facing the gullet.

It is concluded that the unerupted backwardly directed teeth of *Hydrocyon lineatus* face the gullet to control the movements of the living gum and, as with the replacement teeth of other animals (except in the earliest stage of development), face in the direction in which they will function. Radiographic examination and dissection reveal but two rows of teeth, without provision for replacement. One of them is firmly fixed to the jaw and the other freely movable, with possibly more use than that of similarly placed selachian teeth but, like them, retaining their recumbent position throughout the life of the fish.—F. GORDON CAWSTON, *Brittania Buildings, West St., Durban, South Africa.*

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1 I am grateful to Dr. J. C. Broome, F.R.S., for previously directing my attention to this interesting dentition, with its convergent resemblance to that of the Teleostei and selachians, and to Professor W. K. Gregory, who finds no evidence of the existence of more than the two sets of teeth in dried jaws, one set erect and described as "functional" and the other directed backward beneath the gum. I am grateful to Dr. W. McCagie, B.D.S., for radiographing some of the jaws and to Professor M. R. Drennan for a careful description of that part of the jaw I sent him.

RECORDS OF THE LAMPREY (*ICHTHYOMYZON GAGEI*) IN OKLAHOMA AND TEXAS.—In their revision of the lamprey genus *Ichthyomyzon* (Misc. Publ. Mus. Zool., Univ. Mich., 35, 1937), Hubbs and Trautman described *Ichthyomyzon gagei* and recorded it definitely from two localities in Louisiana and one in southern Alabama. In addition, they provisionally identified two ammocoetes taken in Elk River at Turkey Ford, Delaware County, Oklahoma, as the same species.

Two adult specimens of *Ichthyomyzon gagei* Hubbs and Trautman, recently received by the Museum of Zoology, make it possible to verify the northwestern extension of the range to include northeastern Oklahoma and to extend the known geographic limit to the southwest to include eastern Texas. The Texas specimen apparently constitutes the first record of a lamprey from the state. Hubbs and Trautman indicated on their distribution map (*loc. cit.:* 44) that *I. castaneus* and its nonparasitic derivative *I. gagei* occur not far from the eastern border, but no Texas locality was listed for either species.

The Oklahoma specimen, U.M.M.Z. No. 119976, was collected in Barren Fork Creek (tributary to Illinois River), 10 miles east of Tahlequah, Cherokee County, in April, 1931, by Jack Baker, and was received from Dr. George A. Moore on June 14, 1937. This is not far from the Elk River locality whence Hubbs and Trautman reported ammocoetes. Moore (Proc. Okla. Acad. Sci. (1932) 1933, 13: 11) reported this specimen as *Reighardina unicolor*, and attributed to it a length of 161 mm. Now, after 15 years in preservative, it measures 150 mm. in total length—still notably larger than the longest specimen examined by Hubbs and Trautman (126 mm.). The Texas lamprey, U.M.M.Z. No. 143018, was taken in a creek 7 miles south of Douglas, Nacogdoches County, in April, 1936, by Mr. Addison Lee.

The characters given below are those of the Oklahoma and Texas specimens, respectively. Total length, 150.0 and 109.5 mm.; myomeres between last gill-aperture and anus, 55 and 54; supraoral cusps, 3 and 3; infraoral cusps, 11 and 8; teeth in circumoral row, 23 and 21; teeth in anterior row, 4 and 4; teeth in lateral rows, 7–6 and 6–?; bicuspid circumorals, ? (?–3) and 8 (4–4); transverse lingual lamina, weakly developed, moderately bilobed in the Texas example, without cornification (in both), without denticulations except for 2 weak ones on one side of the Texas specimen. Proportionate measurements, expressed in thousandths of the total length, are as follows: length of tail, 290 and 306; depth of body, 55 and 68; length of eye, 13 and 11; length of snout, 49 and 52; length of disk, 43 and 32; and length over gill openings, 101 and 100.—REEVE M. BAILEY, *Museum of Zoology, University of Michigan, Ann Arbor, Michigan.*

NOTES ON FISH COLLECTED AT PASS CHRISTIAN, MISSISSIPPI.—In February, 1946, the authors spent a week collecting fishes in the vicinity of Pass Christian, Harrison County, Mississippi. All specimens were from Mississippi Sound, a body of water separated from the Gulf of Mexico by a chain of islands lying about 4 miles off shore. They were identified by Mr. Henry W. Fowler of the Academy of Natural Sciences of Philadelphia and are now deposited in that institution. The following is a list of the specimens collected:

Micropogon undulatus (Linnaeus)—33
Sardinella anchovia Valenciennes—4
Querimana gyrans Jordan and Gilbert—16
Lagodon rhomboides (Linnaeus)—10
Harengula pensacolae Goode and Bean—1
Anchoa sp.—1

Mr. Fowler, in a letter to us dated May 7, 1946, stated that there were: "Twelve specimens representing a small round herring I am unable to identify with any known genus or species, and it may be something new?"

It is interesting to note that none of the above species are listed for Mississippi in Fowler's recent study of the fishes of the southern Piedmont and coastal plain (Academy of Natural Sciences of Philadelphia, Monograph 7, 1945).—WILLIAM F. RAPP, JR. and JANET L. C. RAPP, *Champaign, Illinois.*

MIXTURE OF MARINE AND FRESH-WATER FISHES IN THE LOWER SALINAS RIVER, CALIFORNIA.[1]—Six collections of fishes made near the mouth of the Salinas River, California, on August 3 and 11, 1946, yielded a curious mixture of marine and fresh-water forms. The stations (1 to 6) ranged from the mouth of the river to the first signs of definite current, 3 miles upstream. During the summer and fall these localities are separated from the ocean by a sand bar, which effectively blocks the ingress of salt water. An inspection on August 11 indicated that the extreme surge of the previous high tide (+5.2 feet) reached a point 2 feet below the top of the bar. Chlorinity determinations made at the same time as the collections (on the preceeding day at Station 4) showed from 0.57 to 1.02 grams of chloride per liter. This represents a salinity of only about one fifteenth or less than that of the ocean water of the open coast. Determinations made in other years at Station 4 have shown the salinity to reach values as high as one third that of the ocean water, probably due to the breaking of waves over the bar during periods of rough water. The area, with the exception of Stations 5 and 6, frequently shows a mixture of a marine alga, *Enteromorpha*, with such fresh-water plants as *Potomogeton* and *Chara*. At Stations 5 and 6 the vegetation is exclusively fresh-water.

TABLE I

DISTRIBUTION AND ABUNDANCE OF FISHES IN THE LOWER SALINAS RIVER

	Station 1 36°44′48″N. 121°48′15″W.	Station 2 36°44′48″N. 121°48′04″W.	Station 3 36°44′52″N. 121°48′04″W.	Station 4 36°43′54″N. 121°45′50″W.	Station 5 36°42′54″N. 121°45′54″W.	Station 6 36°42′48″N. 121°45′54″W.
Chlorinity	1.02	1.02	0.86	0.81	0.57	0.57
Clupea pallasii	4	—	1	—	—	—
Catostomus mniotiltus	—	1	4	2	4	4
Cyprinus carpio	—	—	—	—	4	3
Orthodon microlepidotus	—	—	—	5	5	4
Ptychocheilus grandis	—	—	—	1	—	—
Rhinichthys osculus	—	—	—	—	1	—
Archoplites interruptus	1	—	—	4	4	4
Cymatogaster aggregatus	1	—	3	1	—	—
Leptocottus armatus	5	4	5	5	3	2
Collus asper	—	—	—	—	—	1
Gasterosteus aculeatus	2	2	3	5	5	4
Eucyclogobius newberryi	—	—	—	3	1	2
Platichthys stellatus	5	4	5	4	4	4

Rare species are indicated by 1, very common species by 5 and those of intermediate abundance by numbers 2 to 4.

All localities were in the main river except Station 3, which was in the upper 100 feet of a comparatively fast flowing irrigation ditch that led off almost the entire flow of the river near the mouth. Stations 1, 2 and 4 were from semi-ponded water, 5 and 6 from slow moving current. Collections 1 and 2 were taken on sandy bottom; the others were from muddy areas. Stations 1, 2 and 3 had very scarce vegetation; at the other places there were thick clumps of *Potomogeton* and fresh-water algae.

On the average the marine species decreased in abundance upstream, whereas the reverse was true of the fresh-water kinds (Table I). All 4 species generally considered as marine, *Clupea pallasii, Cymatogaster aggregatus, Leptocottus armatus,* and *Platichthys stellatus,* were recorded as having been taken from fresh-water by Gunter (1942, Am. Mid. Nat., 28: 305–326), without actual data on salinity. *Clupea pallasii* and *Cymatogaster aggregatus* became rare at chlorinities below 1.0 and apparently dropped out at chlorinities below 0.75. *Leptocottus armatus* and *Platichthys stellatus* were far more tolerant of fresh-water. In collections 5 and 6 *L. armatus* became comparatively rare, definitely approaching the upper limit of its range. In the same collections *P. stellatus*

[1] In the preparation of this note assistance was received from several ichthyologists, in particular Rolf L. Bolin of Hopkins Marine Station of Stanford University, W. M. Chapman of the California Academy of Sciences, Robert R. Miller of the United States National Museum, Reeve M. Bailey of the University of Michigan Museum of Zoology and Carl L. Hubbs of the Scripps Institution of Oceanography of the University of California. Donald C. Scott and others assisted in collecting the material.

had noticeably dropped in abundance but was still common, especially in hauls from deep water, including those from the current of the river.

The conditions at Stations 1 and 2 appeared to be unfavorable for fresh-water fishes. Only *Gasterosteus aculeatus,* a fresh-water fish with well-known tolerance to varied salinities, was at all common, but even this species became rarer at chlorinities above 1.0. Both *Archoplites interruptus* and *Catostomus mniotiltus* were rare. The individuals taken probably can be considered as strays from the less salty water above the irrigation ditch. There the fresh-water forms predominated.

In addition to the 4 marine species noted above, the collections contain 3 fresh-water forms which have not previously been reported from the Salinas River. These are *Cyprinus carpio, Archoplites interruptus,* and *Eucyclogobius newberryi.* Besides the above-mentioned fishes, *Ptychocheilus grandis* may or may not be an addition to the known fauna of the river. Its case merits discussion. Girard (1857, Proc. Acad. Nat. Sci. Phila. 8: 165–213; 1858, Rept. Fishes Mex. Bound. Surv., pt. 2) reported a new species, *P. rapax,* from "Monterey," which locality probably meant the Salinas River, the closest stream that supports cyprinid fishes. Robert R. Miller examined the type specimen of *P. rapax* (United States National Museum, No. 205) and reported (in correspondence) "I do not hesitate to refer this nominal species to *P. oregonensis.*" Presumably on the basis of the assigned type locality of *P. rapax,* Jordan and Evermann (1896, Fishes of North and Middle America: 225) listed the Salinas as being occupied by *P. oregonensis* (these authors wrongly considered *P. grandis* as a synonym of the most northern species, *P. oregonensis*). Having failed to find *Ptychocheilus* in the Salinas River system during his extensive field work, Snyder (1913, Bull. U. S. Bur. Fisheries. 32: 47–72) claimed that *P. rapax* "doubtless owed its assigned locality to a confusion in labels" and suggested that it came from some point considerably to the north of Monterey. He correlated the absence of this fish in the Salinas system and its presence in the Pajaro with the geological history of these rivers. The first specimens that are definitely known to have been taken in the Salinas drainage basin were collected by Carl L. Hubbs and Leonard P. Schultz on September 2 and 3, 1926, in the Salinas River at 35° 51′ 44″ N. Lat., 120° 48′ 29″ W. Long. (University if Michigan Museum of Zoology, No. 94229) and in an upper tributary at 35° 25′ 46″ N. Lat., 120° 36′ 20″ W. Long. (UMMZ, No. 94230). The next records, dated from 1939–1941, came from the upper half of the main stream and most of the major tributaries, but not from the coastal plain. These records were all from the general area where Snyder collected. It is improbable that this fish could have been missing entirely from Snyder's collections if it were nearly as abundant prior to 1913 as it is today. Whether the species is native or was planted (either as discarded bait or along with trout) still remains unsolved, though accidental introduction seems the most plausible idea. The scarcity of records from the coastal plain discredits the idea that the species was introduced from the Pajaro into the Salinas since 1913 by any flood water connections. Nor is there any good reason to suspect an introduction across headwater divides. There are no known headwater diversions and the species, according to the extensive field experience of Leo Shapovalov, is rare in the headwater streams on either side of the boundary divide of the Salinas drainage basin.

Both *Archoplites interruptus* and *Cyprinus carpio* have been planted in California. Their occurrence in the Salinas probably has resulted from such planting. Many large carp, up to 18 inches long, were taken, indicating long establishment of the species.

Eucyclogobius newberryi, a fresh-water river-mouth species, is common only in the lower reaches of the stream. Since Snyder did not record any collections downstream from Salinas, it is not surprising that he did not include this species in his list of fishes.

Another fresh-water species, the minnow *Gila crassicauda,* needs to be added to the list of Salinas River fishes, but only tentatively and with much doubt. In the California Academy of Sciences there is a half-grown specimen (No. 11060) of this species that is recorded as having been collected by Martin and Clark in the Salinas River on October 17, 1923. No specific locality is mentioned but the collection was received from Watsonville (in the Pajaro basin). The field list includes 2 specimens of "minnows," one of which may be the fish in question. At the next following collection, taken on October 26 at Stockton in the lower San Joaquin Valley, 57 minnows were listed. There is a possibility that a specimen or a label was transferred, for this species has been known chiefly

from the lowlands of the Central Valley. Even there it appears to be approaching extinction, probably as the result of the introduction of piscivorous fishes.—CLARK HUBBS, *Natural History Museum, Stanford University, California.*

COMPARATIVE MEASUREMENTS ON A RARE FLATFISH, *CYCLOPSETTA CHITTENDENI* BEAN, FROM THE TEXAS COAST.—On January 23, 1946, Dr. Gordon Gunter obtained 14 specimens of *Cyclopsetta chittendeni* Bean from the nets of a commercial shrimper operating at the whistling buoy 5 miles off Port Aransas, Texas, in about 10 or 12 fathoms of water. Many more specimens of these fish were returned to the water.

This is a remarkable record, for up to this time there have been only 7 specimens of this fish in the museums of the world. B. A. Bean (Proc. U.S.N.M. 17: 635–636) described the type from Trinidad in 1895 from a 172 mm. specimen. Norman, (Systematic monograph of the flatfishes, 1934, I: 136–137) described 4 more, a 205 mm. specimen from Trinidad; two 207 and 230 mm., from the Gulf of Paria; and one, 210 mm., from Port of Spain. In 1940, I obtained 2 more at Galveston that were identified by Earl D. Reid (1941, Jour. Wash. Acad. Sci., 31, No. 5). These were 83 and 91 mm. long respectively.

The following table gives comparative measurements for the 14 obtained by Dr. Gunter:

Depth Body in Head	Head in Body	Eye in Head	Max. in Head	Lower Jaw in Head	Dorsal Count	Anal Count	Pect. Count	Pect. in Head	Length Overall	Standard Length
2.22	3.58	5.2	1.79	2.2	85	64	15	2.34	287	244
2.19	3.8	4.9	1.83	2.32	87	66	16	1.84	255	222
2.17	3.74	4.76	1.87	2.2	84	64	13	1.87	260	222
2.2	3.44	4.8	1.84	2.1	85	68	14	2.12	283	235
2.18	3.41	4.28	1.93	2.22	84	64	16	1.51	236	*205
2.2	3.85	4.7	1.74	2.03	83	64	15	1.8	270	235
2.16	3.41	4.13	1.87	2.3	83	65	14	2.00	250	212
2.2	3.58	5.1	1.84	2.09	88	68	15	2.76	195	165
2.08	3.43	5	1.94	2.22	86	64	15	1.81	242	206
2.19	3.68	4.84	1.66	2.1	84	64	14	2.03	272	232
2.15	3.52	4.2	1.85	2.25	88	67	15	2.25	261	222
2.3	3.81	4.88	1.76	2.00	85	66	15	1.83	192	168
2.23	3.33	5.6	1.88	2.21	84	67	14	1.95	200	170
2.3	3.72	4.7	1.88	2.1	86	64	15	1.8	205	175

*Deformed caudal.

Apparently this flounder is quite common offshore in deep water during the winter.—J. L. BAUGHMAN, *Game, Fish and Oyster Commission, Rockport, Texas.*

REVIEWS AND COMMENTS

ALASKA'S ANIMALS AND FISHES. By Frank Dufresne. A. S. Barnes and Company, New York, 1946: i–xvi, 1–297, 92 figs., several colored plates; $5.00—This book is the work of a man who knows Alaska with an intimacy that comes only from long first hand experience. During 22 years as an agent of the old Biological Survey and the Alaska Game Commission, Mr. Dufresne travelled 17,000 miles in Alaska by dogteam; he has flown over it extensively by plane and has explored along its rugged coast by boat. He is an expert hunter and fisherman, and a skilled student of natural history. So he knows his subject from all sides. Most of the book is devoted to mammals, including the seals, whales and porpoises. A long chapter of 87 pages, "A Fisherman Looks at Alaska," concerns the fishes, mostly fresh water species, but includes a few of the more interesting marine ones. This is no museum worker's book, or even a field handbook, but one to browse over with enjoyment during the long winter evenings. The colored plates of Bob Hines are impressively handsome.

BLUE-WATER MEN AND OTHER CAPE CODDERS. By Katherine Crosby. The Macmillan Co., New York, 1946, 288 pp.; $3.50.—This is a collection of sketches about Cape Cod towns, houses, and people, including the few remaining captains of the old sailing days.

THE OCEAN BOOK. By John V. Beaty. Beckley-Cardy Co., Chicago, 236 pp., 75 figs.; $1.35.—Two boys and the author explore the sea from between the tide lines to the ocean depths. They learn about the life cycles and struggle for existence of oceanic creatures; about tides, currents, and waves; earthquakes and volcanoes in the ocean; and how the sea influences the life of man. This is a book for children five to eight years old.

TIGERS OF THE SEA. By Charles G. Muller and Horace S. Mazet. Westminster Press, Philadelphia, 1946, 223 pp., several figs.; $2.00.—This is a story about two college undergraduates who put off from Nova Scotia on a shark hunting expedition. So successful are they that they go to the Pacific "in search of a whale shark, called Cocos Sam, reported loitering around Cocos Island." There is an appendix of notes on "sharks, whale sharks, and shark fishing." The fictional part of the book is good enough reading. The notes contain considerable useful data on sizes of sharks (identified only by common name), on the sizes and oil content of their liver, on seasons of catch, and on the costs and profits of shark fishing. Unfortunately these data are interspersed with a great deal of misinformation which the authors could have avoided by doing a little reading before writing their book.

THE COMING OF THE POND FISHES. By Ben Hur Lampman. Binfords and Mort, Portland, Oregon, 1946, i–xii, 1–167, several figs.; $2.50.—The introduction of exotic species of fishes into the rivers of western United States is one of the most curious episodes in the history of conservation. In the case of some species, like the carp, it is one of the most tragic. It is interesting to learn what went on in the minds of those who made these introductions, and of the circumstances under which the introductions were made. With a sly and engaging humor, Ben Hur Lampman recounts the transport and planting of carp, catfish, the black basses, the crappies, bluegills, yellow perch and bullfrogs. The index is one of the best I have seen, with brief summaries for each item. —L. A. WALFORD, *U. S. Fish and Wildlife Service, Washington, D.C.*

1946 NATIONAL FISHING GUIDE, compiled by William Voigt, Jr. A. S. Barnes & Company, 1946: 1–256, illus.; $1.00.—This is a practical and convenient guide to sport fishing in the United States, telling "where and when to fish and for what." Information, classified by states, ranges over a great miscellany of topics from local fishing laws to indigenous insect pests. This book should be useful to anglers, tourists, and conservationists. It is well illustrated with maps and photographs.—RACHEL CARSON, *Fish and Wildlife Service, Washington, D. C.*

EDITORIAL NOTES AND NEWS

Western Division

THE WESTERN DIVISION of the Society held its sixteenth annual meeting on June 17-18, 1947, at San Diego, California, with the Pacific Division of the American Association for the Advancement of Science. All sessions were held jointly with the Herpetologists League. Two half-day programs of papers were given and there were two symposia, on "Overcoming obstructions to movements of fishes in rivers," and "Speciation in terrestrial cold-blooded vertebrates." For two symposia, the Western Society of Naturalists joined with the other two organizations. Attendance at the various sessions ranged from 40 to 70.

Three student awards were granted: first in ichthyology, to BOYD W. WALKER, timing of grunion runs; second in ichthyology, J. L. MCHUGH, races of herring (*Clupea pallasii*) in California; second in herpetology, to CHARLES H. LOWE, JR., the sedentary nature of reptilian populations, and the *Rhinocheilus* problem.

The following new officers were elected:

President: W. I. FOLLETT, 3501 Broadway, Oakland 11, California.

Vice-President: ROSS HARDY, Weber College, Ogden, Utah.

Secretary-Treasurer: FRANCES N. CLARK, California State Fisheries Laboratory, Terminal Island Sta., San Pedro, California.

News Notes

A NEW international journal is beginning publication, to cover the fields of hydrobiology and protistology. It will be called ACTA HYDROBIOLOGICA ET PROTISTOLOGICA. The Managing Secretary is PROF. P. VAN OYE, University of Ghent, Belgium. Additional members of the Board of Editors will include PROF. KAJ BERG, University of Copenhagen, Denmark; PROF. F. E. FRITSCH, University of London, England; PROF. WILLIAM RANDOLPH TAYLOR, University of Michigan, Ann Arbor, Michigan, and DR. MRS. N. L. WIBAUT-ISEBREE-MOENS, Amsterdam, Holland.

"THE AQUARIUM JOURNAL," official organ of the San Francisco Aquarium Society, appeared in an enlarged and improved format beginning with the January 1947 issue. The Journal, second oldest of existing American aquarium magazines, is now in its eighteenth annual volume. The editor, DR. WILBERT M. CHAPMAN, Curator of Fishes in the California Academy of Sciences, Golden Gate Park, San Francisco, has announced a new editorial policy: "A magazine for amateurs written by professionals, covering the field of aquatic biology." The annual subscription, including membership in the Society, is $2.00.

The $1,000 award of the American Federation of Soroptimist Clubs to the foremost woman in the field of world statesmanship and unity was made for 1946 to DR. BERTHA LUTZ, noted herpetologist and naturalist of the Brazilian National Museum at Rio de Janeiro. Dr. Lutz was formerly a member of the Brazilian Chamber of Deputies, and was one of the Brazilian delegates to the United Nations conference in San Francisco.

The TEXAS GAME, FISH AND OYSTER COMMISSION has started construction of its Marine Laboratory, which should be finished sometime this year. It is situated at Rockport, Texas, and will be a two-story concrete and brick building 40 x 60 feet. When it is completed, the laboratory facilities (including the three boats now in operation) will be available to independent investigators. There will be a staff of three biologists as well as other necessary personnel.

The Commission has announced an opening for an applied fisheries biologist, preferably with experience on crabs and oysters, to start September 1. Application should be made to J. L. BAUGHMAN, Chief Marine Biologist, Game, Fish and Oyster Commission, Rockport, Texas.

DR. JOHN D. BLACK has accepted an Assistant Professorship in the Department of Zoology at Eastern Illinois State Teachers College, Charleston, Illinois, effective at the beginning of the fall term, 1947. Doctor Black has formerly been Head of the Department of Biology at Anderson College, Anderson, Indiana.

DR. ETHELWYNN TREWAVAS has returned to the British Museum from an interesting two-months trip to Nigeria, where she spent most of her time investigating the fish fauna of the Mangrove area, with particular attention to the mullets.

DR. FERNANDO DE BUEN, honorary foreign member, writes that he has now started work in his new post, that of *Jefe del Departmento Cientifico*, Servicio, Oceanografico y de Pesca, Call 18 Julio, Num. 953, Montevideo, R. O. del Uruguay.

GEORGE V. HARRY, a graduate student at the University of Michigan, and GEORGE N. WASHBURN, until recently Biologist, Institute for Fisheries Research, Michigan Department of Conservation, Ann Arbor, have assumed new duties with the Ozark Fisheries, Incorporated, Stoutland, Missouri, a company devoted to the commercial production of goldfish and bait minnows. MR. C. TROY YODER replaces Mr. Washburn on the staff of the Institute for Fisheries Research.

SIDNEY SHAPIRO, who finished his doctoral dissertation on *Fundulus diaphanus* at the University of Michigan in February, left soon after for Tokyo to assume a post in the War Department's program for the rehabilitation of the Japanese fisheries. His address is: Fish Division, Natural Resources Section, G.H.Q., S.C.A.P., A.P.O. No. 500, c/o Postmaster, San Francisco, California.

WILLIAM F. SIGLER, Department of Zoology and Entomology, Iowa State College, has completed his investigation of the life history of the white bass, and has accepted a position with the Wildlife Management Department, School of Forest, Range, and Wildlife Management, Utah State Agricultural College, Logan, Utah.

PROF. J. L. B. SMITH of Rhodes University College, Grahamstown, South Africa, writes that he resigned last year from his lectureship in chemistry to become Professor of Biology, so that he might have more time for ichthyological research. He has in advanced stage of preparation a thoroughly illustrated monograph on South African fishes. He is laying plans for a large-scale expedition to seek new material of *Latimeria*, the greatest ichthyological discovery of the century.

WILLIAM HERRINGTON has temporarily transferred from the Fish and Wildlife Service to become Chief of the Fisheries Section, Japanese Military Government, for about two years.

THE COLLEGE OF MEDICAL EVANGELISTS, Loma Linda, California, is establishing a School of Tropical and Preventive Medicine. Courses designed particularly for laymen will include instruction in hygiene, insect and rodent control, general sanitation, medical emergencies and elementary medicine. The training program for physcians will be designed to give a comprehensive knowledge of tropical diseases, followed by field work at certain clinical training stations in the tropics. One of the objectives is to emphasize the biological aspects of tropical medicine. The new school is anxious to obtain old editions of COPEIA, and authors' reprints relating to any phase of ichthyology or herpetology. These should be sent to DIRECTOR HAROLD N. MOZAR, School of Tropical and Preventive Medicine, at the above address.

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